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MECHANISM OF MILL-ADDED OPACITY IN PORCELAIN ENAMELS*

By Andrew I. Andrews and Burnham W. King, Jr.

Abstract

The microscopic appearance of sheet-iron, white cover enamels indicates that mill-added opacifiers function principally as layers between the frit particles and do not diffuse well into the enamel. This explains the reasons why (1) mill-added opacifiers do not continue to increase reflectance when added in large quantities, (2) increased fineness of milling aids reflectance, (3) extreme fineness of opacifiers is necessary, and (4) transparent glassy frits appear mottled with mill-added opacifiers. From these observations it is evident that increased reflectance of enamels originates in the frit or is brought about either by finer milling or by better diffusion of mill-added opacifiers.

I. Introduction

The reflectance of sheet-iron cover enamels increases with an increase of mill-added opacifiers only to a limited extent. If the frit is not very opaque, the increase is rapid at first, but with additional amounts of opacifier the rate decreases, and further additions give less and less increase in reflectance. Opaque frits approach maximum reflectance with a smaller addition of opacifier than is required for less opaque frits, and they never gain as much marginal reflectance* although the total reflectance may be greater.

II. Microscopic Studies

A microscopic study was made on thin sections of cover enamels to determine the cause of this behavior. A frit with low reflectance was selected and to it was added 8% tin oxide, 4% clay, and 45% water. Three batches were milled as indicated in Table I.

Table I

Milling	Revolutions	Fineness (g./100 g. frit)	
		On 100 mesh	On 200 mesh
Coarse	5,000	10.5	37.9
Medium	10,000	None	4.0
Fine	14,000	None	None

These enamels were applied over normal sheet-iron ground coats and were dried and fired. Thin sections of the dried enamel and enamel fired for $1^1/_2$, 3, and 6 minutes were made and were examined under magnifications of 150× and 1000×.

III. Results

Figures 1 to 3 show photomicrographs of some of these sections; Fig. 4 shows the reflectance at 40 grams per sq. ft. The dark sections are particles of frit; the light sections are mill additions. The clay covers many of the frit particles in the dried enamel and makes observations difficult; in the fired samples, the frit particles are readily seen, and the opacifier appears as white material in the interstices. Even with six minutes of firing the opacifier does not diffuse far into the frit particles. This is quite evident in the figures showing high magnifications.

The authors interpret these results to mean that because the mill-added opacifier does not diffuse to any great degree into the frit particles, only amounts sufficient to fill the interstices can do any appreciable good as an opacifier. Packing excessive amounts in the interstices, thereby pushing the frit particles apart, would not theoretically and does not practically increase the reflectance to any great extent.

These results show that an increased degree of milling obviously will develop more interfaces and thereby will increase the reflectance possible from mill-added opacifiers. This effect of milling on the reflectance, which has been proved by other investigators,[1] is shown by Fig. 4.

The high reflectance of the dried enamel coating undoubtedly is caused by gas opacity. As the enamel softens during firing, the frit particles fuse together which forces out the air and lowers the opacity of the enamel.

In Fig. 3*A*, the clay and opacifier may be seen as distinct particles along the edges of the frit grains which appear black in the photomicrograph. After the enamel has been fired for $1^1/_2$ minutes (see Fig. 3*B*), a stage of sintering or incipient fusion is reached. The small particles along the edges of the large frit grains are less distinct because the frit has softened enough to allow them to become embedded in its surface, causing its outline to appear ragged. There may also be some sintering between the clay and opacifier particles. After three minutes, the normal firing time for this enamel, a definite bonding has taken place between the frit grains. Figure 3*C* shows a large frit grain with a row of small bubbles along its lower edge which is horizontal in the photomicrograph. Fine particles from the mill addition, which are much less distinct than in the previous figure, may be seen along the boundary. Figure 3*D* shows a large frit grain with an occasional bubble along its edge. Thus, even after six minutes' firing, the boundaries of the frit grains are still distinct.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 30, 1938 (Enamel Division). Received April 21, 1938; revised copy received February 28, 1939.

* Marginal reflectance is the difference between the reflectances of the enamel with and without the mill-added opacifiers.

[1] (*a*) J. D. Tetrick, "Opacity Development in Cover Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, **18** [10] 314–18 (1935).

(*b*) F. R. Porter and H. H. Holscher, "Use of Finely Milled Enamel Slips," *ibid.*, **18** [2] 39–42 (1935).

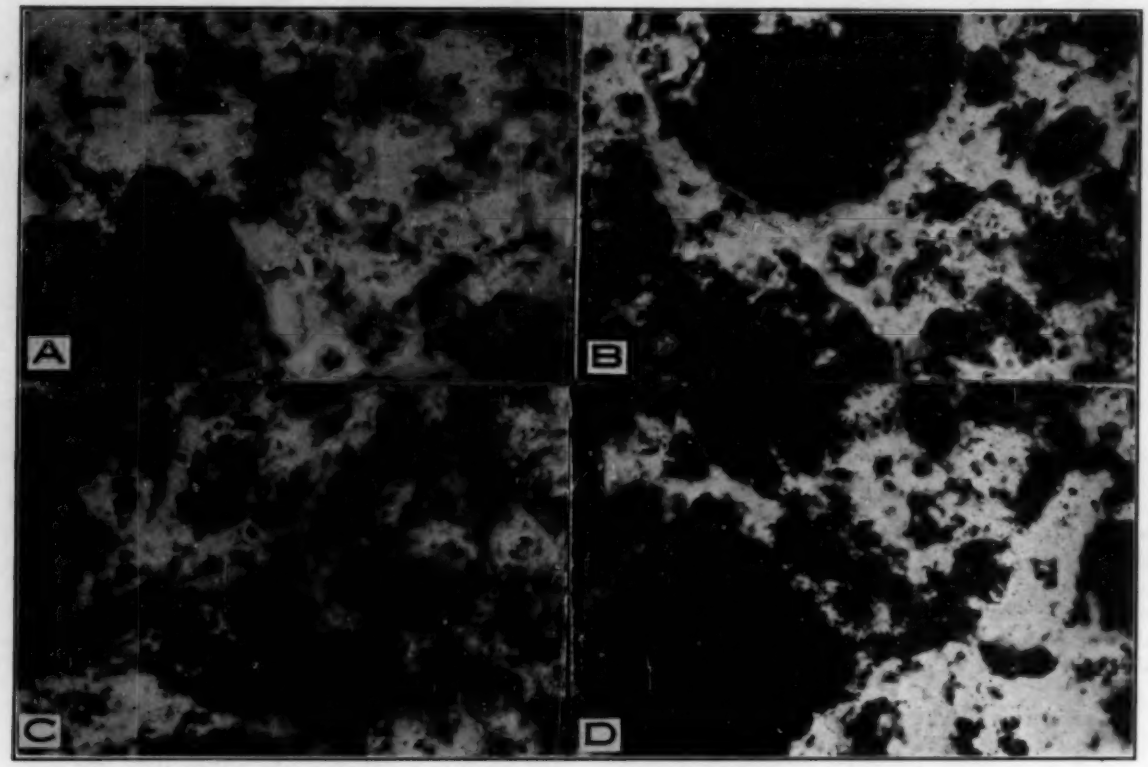

FIG. 1.—Coarse milling, 150×: *A*, dried; *B*, fired 1½ minutes; *C*, fired 3 minutes; *D*, fired 6 minutes.

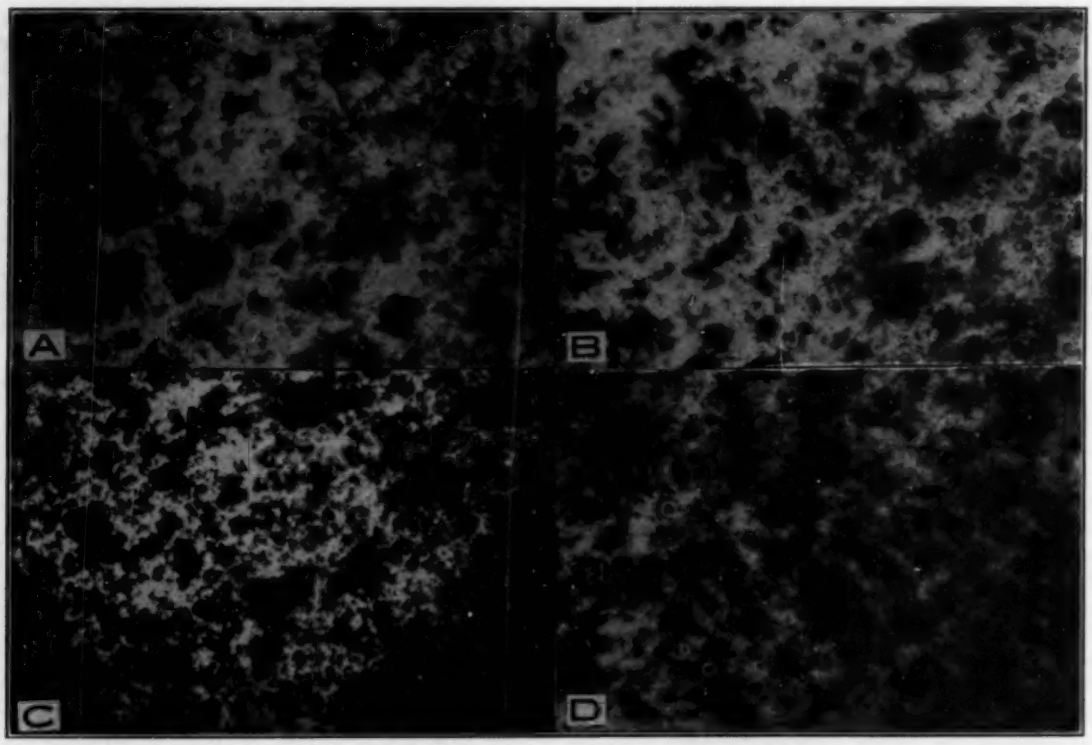

FIG. 2.—Fine milling, 150×: *A*, dried; *B*, fired 1½ minutes; *C*, fired 3 minutes; *D*, fired 6 minutes.

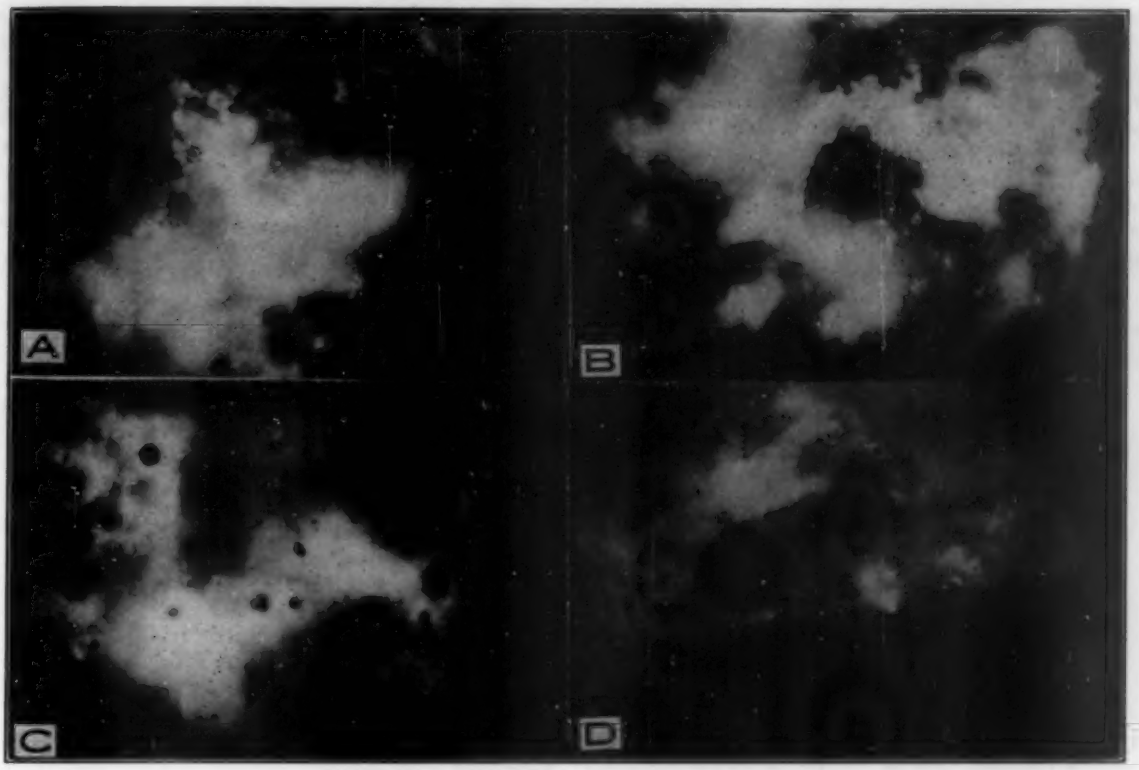

FIG. 3.—Coarse milling, 1000×: *A*, dried; *B*, fired 1½ minutes; *C*, fired 3 minutes; *D*, fired 6 minutes.

Enamels with highly opaque frits do not need large amounts of mill-added opacifiers, as the interface represents only a limited part of the surface area, and the penetration of the light into these enamels is not sufficient to bring into play much of the opacity caused by the opaque layer between the grains.

The gases evolved during firing an enamel bring about some agitation of the fused frit; in some cases, this destroys the original outline of the grains, but it is not sufficient to cause insoluble opacifier compounds to diffuse through the enamel.

A frit of low viscosity at the firing temperature probably would show more diffusion than a more viscous frit. The enamel used was a commercial frit firing to a good gloss in three minutes at 1500°F. Its viscosity at the firing temperature probably is fairly typical of the enamels now in use.

Further observations of enamels in general support the interpretation of the experiments described here.

(1) If the frit is not opaque, it is not possible to add mill opacifiers and get as high reflectance as can be obtained by using an opaque frit (unless the frit is ground very fine, in which case greatly increased opacity is obtained).

(2) If the frit is not opaque and if large amounts of opacifier are added, a mottled appearance is produced unless the frit is ground very fine.

(3) If a white frit is used with insoluble color oxides, the color is confined to the space between the frit particles. The enamel appears mottled if the frit is not ground fine. The color intensity is influenced by the fineness of grinding, just as the opacity caused by mill-added opacifiers is affected.

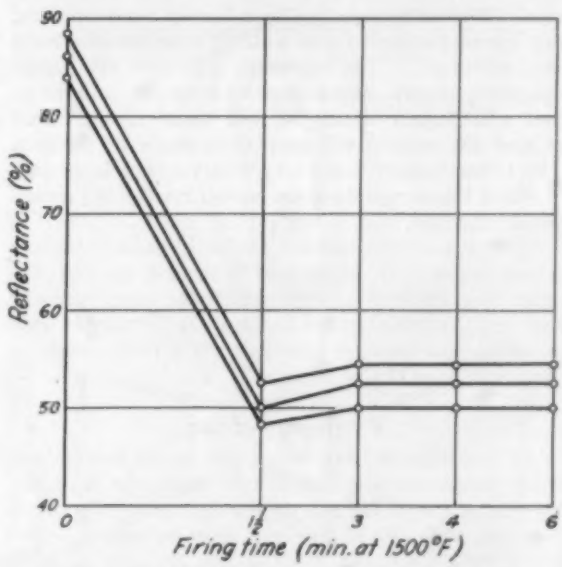

FIG. 4.—Effect of firing time and fineness on reflectance at 40 grams per sq. ft.: *top curve*, fine; *center*, medium; *lower*, coarse.

IV. Summary

The mill-added opacifiers remain between the frit particles and do not diffuse uniformly through the glass when it is fired. This explains why mill-added opacifiers are not as efficient as opacifiers added in the frit.

If these results are accepted as generally true, the problem of developing more opaque enamels is clarified, but it is no less difficult. The improvements obviously are not to be found in mill-added opacifiers unless they are milled fine or unless some method is devised to make them diffuse into the enamel particles. This seems to be difficult to accomplish to any great degree at the present time.

Inasmuch as the amount of opacifying particles present in frits is actually small compared with other coatings, great increases in reflectance may possibly be developed by new methods of incorporating more opacifier in a dispersed condition.

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SAG-RESISTING PROPERTIES OF ENAMELING IRON*

By Frank R. Porter

Abstract

A method is given to determine the sag-resisting properties and the effect of the composition of enameling iron, its gauge, and the temperature on sag values. A theoretical consideration of the deflection of beams is also given. Two types of test strips, one 12 inches long supported near the ends and the other 5.55 inches long and supported at one end, were used. Both types have merit, but the 12-inch strip seemed to give better results. The composition of the iron seemed to affect the sag values, *e.g.*, mild steel, with more carbon and manganese, showed higher sag values than enameling iron. The heavier gauge values decreased the amount of sag. Sag values increased with increase of temperature, particularly above 1500°F.

I. Introduction

One of the advantages of enameling iron over mild steel is its superior resistance to sagging or deflection at the elevated temperatures used in enameling processes. This difference has been known for some time and several methods for measuring sag resistance have been advanced.[1] The enameling iron used with many enameling shapes should be of such quality and gauge that a minimum of sagging will occur during firing so that the articles will keep their shape or contour. This is particularly important with parts of large area in which the design does not permit reinforcing means to be employed.

Several questions naturally arise in considering sag resistance, such as the method of making the test, the effect of variations in temperature, the composition of the metal, and the gauge and size of the sample used in making the test. A consideration of these questions forms the basis of this paper.

II. Theory of Sag

An iron strip or beam supported at the two ends at room temperature will deflect between the supports, the amount of deflection depending upon several factors such as length of strip and its cross section. This deflection does not deform the strip beyond its elastic limit, that is, there is no permanent deformation. Such deflection is subject to calculation.[2]

For the usual gauges of enameling iron sheets and short lengths, such as are used in making sag determinations, there is no appreciable deflection at room temperature. At temperatures, however, such as those used in porcelain enameling, there is a definite and permanent sag. The sag is the result of two changes that occur in the iron with increasing temperature. As the temperature is raised, there is a more or less uniform decrease in elastic limit and ultimate strength which results in sagging. At a definite temperature (about 1650°F), the iron undergoes a rearrangement of its atoms. While passing through this "critical temperature," the iron is much weaker than it is at higher or lower temperatures. The presence of carbon and manganese causes atomic rearrangement and a consequent weakening of the steel over a range of temperature, starting at about 1320°F. The upper limit of the temperature range is dependent upon the amount of the elements present.

III. Method Used to Determine Sag

One of the first records of a method to measure the sag-resisting properties of enameling iron is that proposed by Butts.[1(a)] Strips of the metal to be tested, $^1/_2$ by $9^1/_8$ inches, were supported near the ends by a frame of $^1/_2$-inch angle iron. The frame and test strips were heated at 1600°F for 10 minutes. After removing from the furnace and cooling, the sag was measured at

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received April 18, 1938; revised copy received February 14, 1939.

[1] (*a*) Homer Butts, "Checking Sag-Resisting Properties of Enameling Iron," *Better Enameling*, **3** [6] 21 (1932); *Ceram. Abs.*, **11** [12] 607 (1932).

(*b*) E. C. Aydelott and W. H. Pfeiffer, "Enamel Shop Control," *Better Enameling*, **6** [3] 12–17 (1935); *Ceram. Abs.*, **14** [6] 133 (1935).

[2] M. S. Ketchum, Structural Engineers Handbook, p. 657, 3d ed., enl. McGraw-Hill Book Co., New York, 1928.

the center of the strip. This method, or some variation of it, is in general use today.

Another method which has been suggested and is employed at least in one control laboratory is to use a shorter test strip, 2 by 6 inches, held at one end with one end free to sag.

Both types of tests were used in the present work, except that different sizes were used and the equipment and the method were as follows:

(1) Test Furnace

An electric furnace of 15 kw. capacity with a heating chamber, 12 by 8 by 26 inches, was used. The furnace was equipped with a recording potentiometer controller which held temperatures to ±5°F. No protection was used on the thermocouple. A temperature "overshoot" of approximately 10°F was obtained in the furnace "come-back" (see Fig. 1), which shows the temperature record of a number of sag tests.

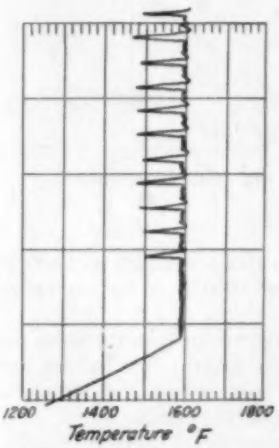

FIG. 1.—Temperature record of a number of sag tests.

(2) Supporting Frames

Figure 2 shows the supporting frame used. It was constructed of a 1/4-inch heat-resisting rod; the supporting rods are on 9-inch centers and are 6 1/4 inches above the base. One side of the frame was equipped with a support for the cantilever type of test strips. This method was found to be in error because true cantilever conditions are not involved, and another frame was constructed to hold the sample properly (see Fig. 3).

(3) Test Strips

Strips to be tested by supporting near the two ends were 2 inches wide and 12 inches long; those supported at one end were 2 inches wide and 6 inches long. The test strips, sheared from flat sheets, were kept flat before testing because previous work showed this to be important if reproducible results were to be obtained. As a precautionary measure, shearing burrs were also removed from the edges of the test strips.

The 6-inch length test strip was used because trial tests showed that this length, acting as a cantilever beam fixed 0.5 inch from one end, sagged nearly twice as much as the 12-inch strip placed over two supports. This amount of sag (about 1 1/4 inches) was sufficient for the lightest gauge strip used.

(4) Measuring Sag

Figure 4 shows the equipment developed to measure sag in the 12-inch strip. It consists of two studs mounted 9 inches apart on a brass plate. A steel rule (reading in hundredths of an inch) was mounted on the plate midway between the studs with its zero reading in the same plane as the top edges of the studs. Sag was then measured by placing the cooled test strip on the studs and noting the reading on the rule at the bottom of the strip.

The sag of the cantilever-type strips was measured at the free end while the strip was in position on the test frame, which was resting on a flat plate. The difference in the height of the end before and after heating was regarded as the sag.

(5) Composition of Iron

Typical analyses are shown for the enameling iron and for the mild steel which was used in one set of

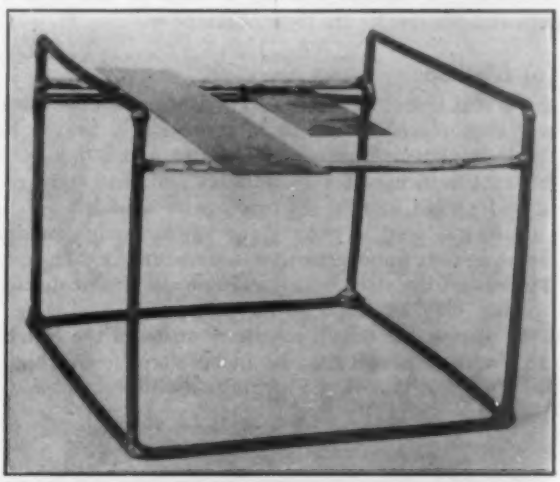

FIG. 2.—Supporting frame for 12-inch strips.

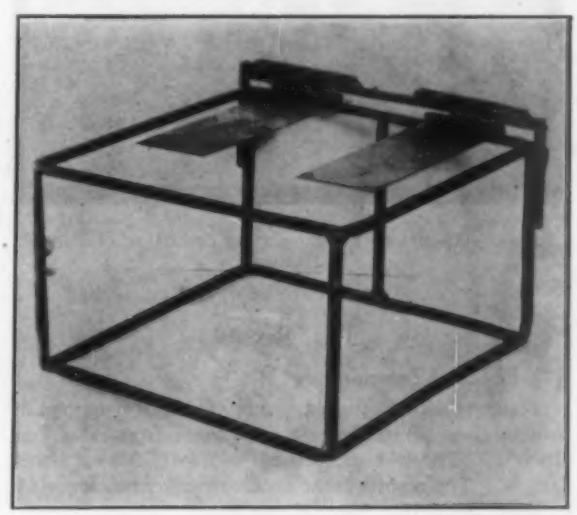

FIG. 3.—Supporting frame for 6-inch strips.

tests in order to compare the sag-resisting properties of these two metals.

	Mild steel (%)	Enameling iron (%)
Carbon	0.10	0.03
Manganese	.35	.05
Phosphorus	.015	.010
Sulfur	.025	.025
Silicon	.005	Trace

Test strips were sheared from production lots of sheets made by the cold reduction process. Enameling iron sheets were open-annealed or normalized; mild steel sheets were box-annealed. The strips were sheared transverse to the rolling direction and from the area of the sheets midway between the two sides. A consistent sampling practice must be adopted if reproducible results are to be obtained.

(6) Method

The flat test strip was placed on the test frame which was then placed in the furnace previously heated to the desired temperature. The frame and strips were left in the furnace for 10 minutes and then were removed, cooled, and the sag readings were made.

Care was used in placing the 12-inch strips on the frame so that the overhang was the same on each end. To prevent the strip from sticking to the frame during heating, clay was used on the supports.*

In placing the 6-inch cantilever strips in the frame, they were so placed that 5.5 inches actually overhung the supports, that is, 0.5 inch was used for "gripping" the strip.

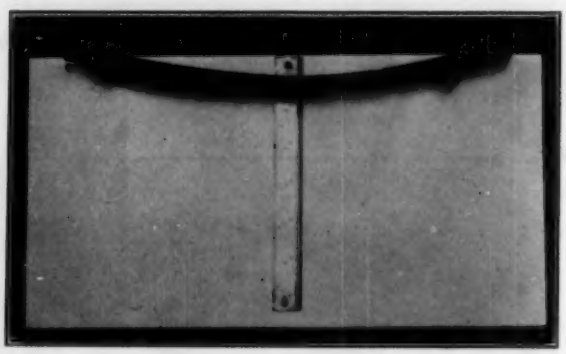

FIG. 4.—Apparatus for measuring deflection of 12-inch strip.

IV. Results

(1) Effect of Temperature

Figure 5 shows the variation of sag for enameling iron and mild steel at temperatures from 1400° to 1600°F. The test strips used were 0.0375 by 2 by 12 inches. The results show about twice as much sag for

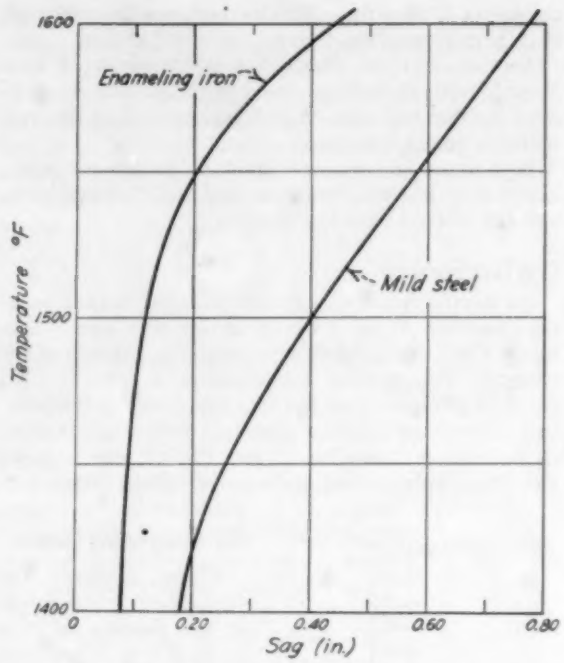

FIG. 5.—Variation of sag with temperature.

mild steel at 1400°F, three times as much at 1500°F, and about twice as much at 1600°F as for enameling iron.

The sagging characteristics of an iron therefore are greatly dependent upon the quantity of carbon and manganese present in the iron; the sag decreases as these constituents decrease within certain limits. The effect of carbon and manganese on the thermal transformation points with their dimensional changes of iron and mild steel has been shown by Porter and Nead.[3] The upper transformation point, A_3, is lower in mild steel than in enameling iron.

The results also show that the rate of increase in sag with increase of temperature for enameling iron is much greater above 1550°F than below this temperature. The sag at 1600°F is twice that at 1550°F. This shows clearly why the use of lower firing ground coats would be advantageous, particularly for those enameled shapes that are subject to warping. It also shows the necessity for definite temperature conditions in making sag determinations if reproducible results are to be obtained. A 10° temperature variation from 1600°F will result in approximately 0.1 inch variation in deflection. One of the laboratories makes sag tests on 0.0375-gauge sheets at 1580°F, which seems to be sensible because the sag variation with temperature variation is less at this temperature than at 1600°F; this tends to introduce less error in the results.

* This was suggested by G. H. Perry of Edison General Electric Appliance Company.

[3] F. R. Porter and J. H. Nead, "Characteristics of Sheet Metal for Porcelain Enameling," *Jour. Amer. Ceram. Soc.*, **21** [1] 9–16 (1938).

(2) Effect of Gauge

Figure 6 shows the relation between sag at 1600°F and the gauge or thickness of metal. Curves are shown for the 12- inch and the 6-inch strips.

The curve for the 12-inch test strip shows sag values from 0.6 inch for the 0.026 gauge to 0.1 inch for the 0.065-gauge strip. The curve for the cantilever-type test strip shows sag values about 70% higher and it is steeper, particularly for the lighter gauges, *i.e.*, the change in sag values with variation in gauge is greater than for the 12-inch strip.

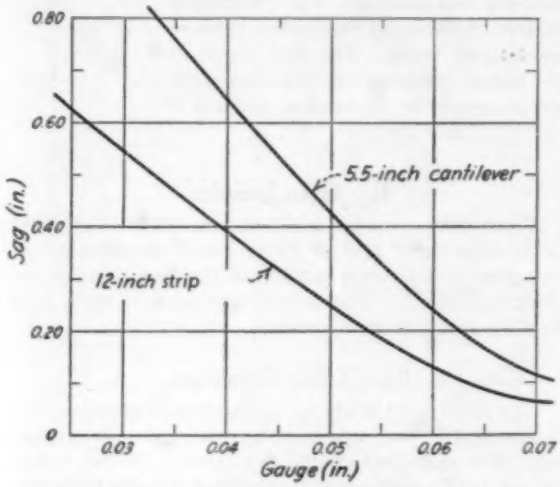

FIG. 6.—Variation of sag with gauge of strip.

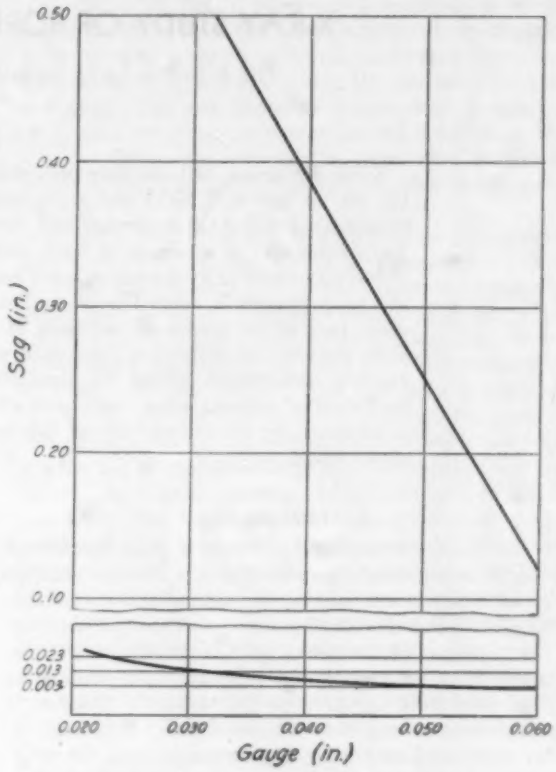

FIG. 7.—Theoretical deflection at room temperature vs. sag at 1600°F.

Comparisons of the actual sag obtained at 1600°F with the theoretical deflection at room temperature give interesting results. Such comparisons may be made on the curves shown in Fig. 7.

(3) Effect of Width

Numerous tests made with test strips 12 inches long and $^1/_2$, 1, $1^1/_2$, and 2 inches wide, respectively, indicate that the width of the test strip does not affect the sag or deformation obtained.

(4) Effect of Time

Determinations made with the 12-inch, 0.046-gauge strips of enameling iron at 1600°F for 10, 15, and 20 minutes, respectively, gave the following results:

Length of time (minutes)	Sag (in.)
10	0.30
15	.37
20	.39

V. Conclusions

(1) Temperature, gauge of metal, and duration of heat treatment are the deciding factors affecting sag for the two types of metal tested. The results indicate that in industry the use of ground coats which mature at lower temperatures than the usual 1580° to 1600°F would help to reduce sagging and warping in enameled shapes. Such ground-coat enamels are in limited use today.

(2) The mild steel tested sagged appreciably more than the enameling iron.

(3) The author favors a sag test method which involves the use of a strip supported near the ends rather than one supported as a cantilever. The test frame is simpler and the test strip is longer, which gives a larger area of sheet and should give more reliable results. There is also less likelihood of error in placing the strip in position for the test. Either method, however, will give satisfactory results.

Acknowledgment

The author expresses his appreciation to the Inland Steel Company for permission to use the material submitted in this paper. He is also indebted to members of the metallurgical staff of the Inland Steel Company for their assistance and criticisms.

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X-RAY STUDY OF BORIC OXIDE-SILICA GLASS*

By J. Biscoe,† C. S. Robinson, Jr., and B. E. Warren

Abstract

X-ray diffraction patterns have been made of four samples of boric oxide-silica glass (15, 30, 45, and 60% SiO_2) and of Pyrex-brand chemical resistant glass. Radial distribution curves for the 5 samples were obtained by the usual Fourier analysis method. The results lead to a picture of boric oxide-silica glass in which each silicon is tetrahedrally surrounded by 4 oxygens, each boron is triangularly surrounded by 3 oxygens, and each oxygen is bonded between 2 cations. In Pyrex-brand chemical resistant glass, part of the borons are probably in tetrahedral coördination. The softening of silica glass by the addition of boric oxide results from replacing in the random network fourfold coördinated silicon by threefold coördinated boron. The low expansion coefficient of vitreous silica, contrasted with the higher expansion of crystalline silica, is explained by the impossibility of coöperative maneuvers in the random network of glassy silica.

I. Introduction

The X-ray diffraction pattern of a glass consists of several broad diffuse peaks. From a Fourier analysis of the X-ray scattering curve, determined experimentally, a radial distribution curve is obtained directly. The positions of the peaks on this curve give the distances from an atom to its neighboring atoms in the glass, and from the area of the peaks the number of neighboring atoms may be calculated. Although X-ray analysis does not by any means give all the information which is needed about the structure of glass, it does give definite information as to the way in which the various atoms are bonded together. It is the obvious first step in building up a structural chemistry of glass.

For simple compositions, the interpretation of the radial distribution curve is fairly straightforward and unique. The more complicated the composition of the glass, the fewer are the unique conclusions which may be drawn. The Fourier method thus far has been applied to the two simple oxides,[1] SiO_2 and B_2O_3, and to the two binary systems,[2] Na_2O–SiO_2 and Na_2O–B_2O_3. The same method of analysis is applied to the system B_2O_3–SiO_2 in this paper. The theory of the Fourier method and the various corrections involved will be omitted here because these points have been outlined in other papers.[2]

II. Glass Samples

X-ray patterns were made of four samples of boric oxide-silica glass* and of Pyrex-brand chemical resistant glass. The compositions of the five samples are given in Table I. The sample used was (in each case) a rod about 1 mm. in diameter.

III. X-Ray Technique

Exposures were made in a cylindrical camera with a radius of 4.40 cm., evacuated to eliminate air scattering. The radiation was MoKα (λ = 0.710 A), monochromated† by reflection from a rock salt crystal. The exposures were of the order of 10 to 20 hours. For each sample, at least two exposures were made, one of which was a long exposure to bring out the weaker detail at large angles of scattering. All films were microphotometered, and the microphotometer records were changed to intensity curves in the usual way.

Figure 1 gives the X-ray intensity curves obtained from the microphotometer records. The intensity curves of the two end members, SiO_2 and B_2O_3, are included for comparison. The intensity is expressed in electron units per unit of composition, and the arbitrary units of composition are listed in Table I.

Table I

Composition of Samples

Sample No.	Composition in weight (%)				Arbitrary unit of composition
	SiO_2	B_2O_3	Na_2O	Al_2O_3	
1	15	85			$Si_{0.189}\ B_{1.583}\ O_{2.831}$
2	30	70			$Si_{0.322}\ B_{1.336}\ O_{2.669}$
3	45	55			$Si_{0.487}\ B_{1.026}\ O_{2.513}$
4	60	40			$Si_{0.616}\ B_{0.730}\ O_{2.385}$
Pyrex-brand	81	13	4	2	$Si_{0.833}\ B_{0.230}\ Na_{0.080}\ Al_{0.034}\ O_{2.090}$

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* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Glass Division). Received March 6, 1939.

† Glass Research Fellow. This paper constitutes the fourth report of work done with the assistance of the Glass Research Fellowship sponsored by seven American glass manufacturers.

[1] (*a*) B. E. Warren, H. Krutter, and O. Morningstar, "Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3," *Jour. Amer. Ceram. Soc.*, **19** [7] 202–206 (1936).

(*b*) B. E. Warren and J. Biscoe, "Structure of Silica Glass by X-Ray Diffraction Studies," *ibid.*, **21** [2] 49–54 (1938).

[2] (*a*) B. E. Warren and J. Biscoe, "Fourier Analysis of X-Ray Patterns of Soda-Silica Glass," *ibid.*, **21** [7] 259–65 (1938).

(*b*) J. Biscoe and B. E. Warren, "X-Ray Diffraction Study of Soda-Boric Oxide Glass," *ibid.*, **21** [8] 287–93 (1938).

* The authors are indebted to W. C. Taylor of the Corning Glass Works for the four samples of boric oxide-silica glass.

† See text note, p. 181.

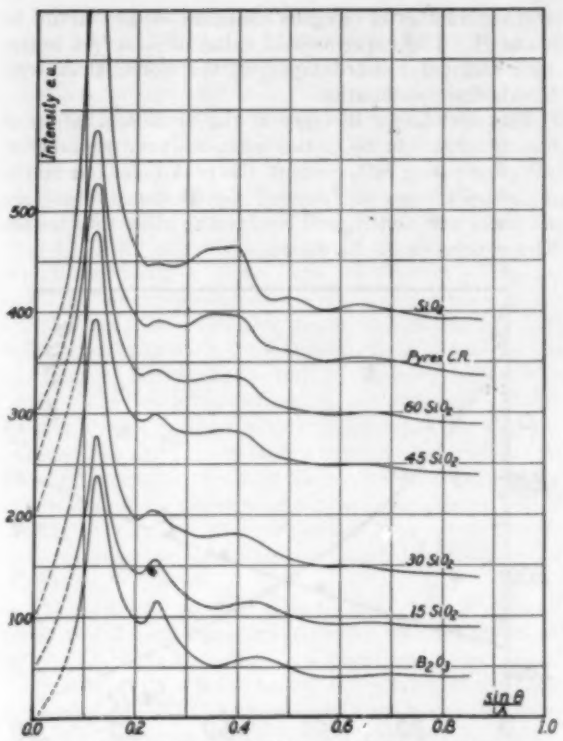

FIG. 1.—Experimental X-ray intensity curves of samples of boric oxide-silica glass. The intensity is expressed in electron units per arbitrary unit of composition given in Table I.

NOTE: The importance of using monochromatic radiation and not too thick a sample is strikingly illustrated by a recent paper by G. Hartleif, "Struktur des Kieselglases und der Kalisilikatgläser," *Z. anorg. allgem. Chem.*, **238** [4] 353–84 (1938).

Using filtered CuKα radiation transmitted through a silica slab 0.43 mm. thick, Hartleif has found a new peak at $\frac{\sin\theta}{\lambda} = 0.06$. This was due to the use of a sample about three times too thick, which absorbs the Kα line badly but passes with much less absorption the shorter wave lengths of the continuous spectrum. The transmitted radiation therefore is a mixture of the Kα line and shorter wave lengths from the continuous spectrum. This is shown by the fact that Hartleif's measured absorption coefficient is 1.24 mm.$^{-1}$, whereas for $\lambda = 1.539$ A in silica glass, it should be 7.5 mm.$^{-1}$ The authors, as an additional check, have made a pattern with filtered CuKα transmitted through a vitreous silica slab 0.43 mm. thick, obtaining a peak at $\frac{\sin\theta}{\lambda} = 0.06$. With monochromatic CuK$\alpha$ radiation and a slab of the same glass about one-third as thick, there is no trace of a peak at 0.06. The new peak, therefore, is wholly spurious and is due to the intensification of the shorter wave lengths by the filtering action of too thick a sample. The conclusions of Hartleif's paper, based upon the discovery of the new peak, must therefore be rejected.

IV. Results of Fourier Analysis

The radial distribution curves obtained by Fourier analysis of the intensity curves are shown in Fig. 2. The distribution curves of the two end members, SiO_2 and B_2O_3, are reproduced from previous work.[1a]

The curves of Fig. 2 represent 3 distribution curves superimposed, *i.e.*, the distribution of neighboring atoms around a silicon, a boron, and an oxygen atom. The position of a peak gives the distance between 2 atoms. The two kinds of atoms may usually be recognized by comparison with known interatomic distances. From the area of the peak, the number of atoms of one kind surrounding the other may be calculated.

In B_2O_3, each boron was found to be triangularly surrounded by 3 oxygens with a B–O distance of 1.39 A. In vitreous SiO_2, each silicon was found to be tetrahedrally surrounded by 4 oxygens with an Si–O distance of 1.62 A. For the boric oxide-silica glasses, the position of the first peak is given in Table II. The values vary between 1.39 and 1.62 A. The first peak is made up of the B–O and the Si–O peaks unresolved, the position depending upon the relative amounts of B_2O_3 and SiO_2. For the 15 SiO_2 and 30 SiO_2 curves, the relative contributions of the B–O and Si–O peaks are indicated on Fig. 2. Assuming that in boric oxide-silica glass each silicon is bonded to 4 oxygens and each boron to 3 oxygens, the area of the first peak may be calculated. In Table II, the areas calculated on this basis are compared with the measured areas. The agreement is within the experimental error and is quite satisfactory.

The second peak, occurring at about 2.5 A, is due to the oxygen-oxygen separation. In the BO_3 triangular groups, the O–O distance should be

$$\text{O–O} = \text{B–O}\sqrt{3} = 1.39\sqrt{3} = 2.40\text{ A.}$$

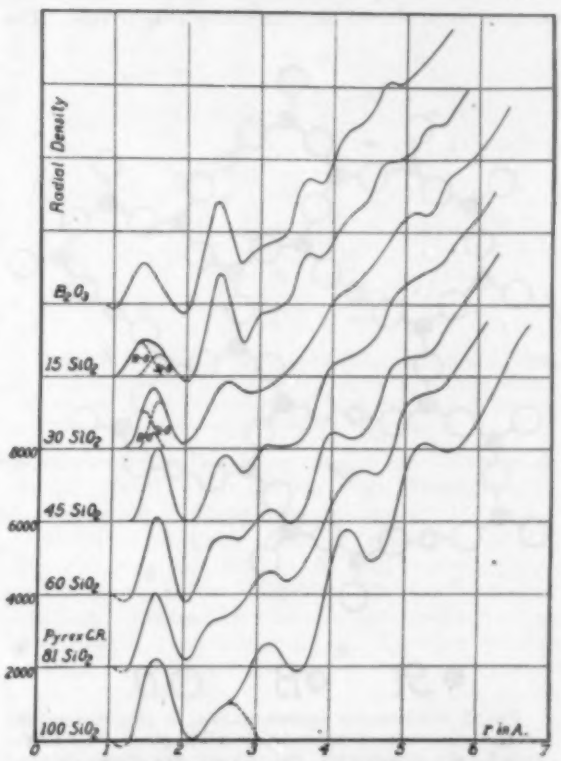

FIG. 2.—Radial distribution curves for samples of boric oxide-silica glass obtained by Fourier analysis.

TABLE II
POSITION AND AREA OF FIRST PEAK

Composition	Position of first peak	Measured area in elect²	Calculated area in elect²
B_2O_3	1.39 A	469	450
15 SiO_2	1.46	530	560
30 SiO_2	1.55	670	637
45 SiO_2	1.62	719	705
60 SiO_2	1.62	747	771
81 SiO_2 (Pyrex-brand)	1.62	800	790
SiO_2	1.62	970	896

In the SiO_4 tetrahedral groups, the O–O distance should be

$$\text{O–O} = \text{Si–O}\sqrt{\frac{8}{3}} = 1.62\sqrt{\frac{8}{3}} = 2.65\,\text{A}.$$

For the two compositions, B_2O_3 and $15\,SiO_2 \cdot 85B_2O_3$, the second peak is resolved well enough to measure its area. In both compositions, the area corresponds to about 5 oxygens about any one oxygen. In a triangular boron-oxygen network, each oxygen would be shared between two BO_3 groups and would therefore have 4 directly bonded oxygen neighbors (2 from each BO_3 group). Because 4 oxygens only partially surround the given oxygen, 1 or 2 more neighboring oxygens from other BO_3 groups would be expected at distances only slightly greater. If, on the other hand, the borons in B_2O_3 were in tetrahedral coördination, the composition would require one-third of the oxygens to be shared between two BO_4 groups and the other two-thirds of the oxygens to be shared between three BO_4 groups. The average number of oxygens about an oxygen would be about 8. The experimental value of 5 agrees better with triangular coördination of the boron than with tetrahedral coördination.

The next larger distance is the Si–Si separation at about 3.2 A. In SiO_2, this peak is very prominent; with decreasing SiO_2 content, the peak fades out on the distribution curves. Beyond this distance, there are no peaks sufficiently well resolved to allow any important conclusions to be drawn.

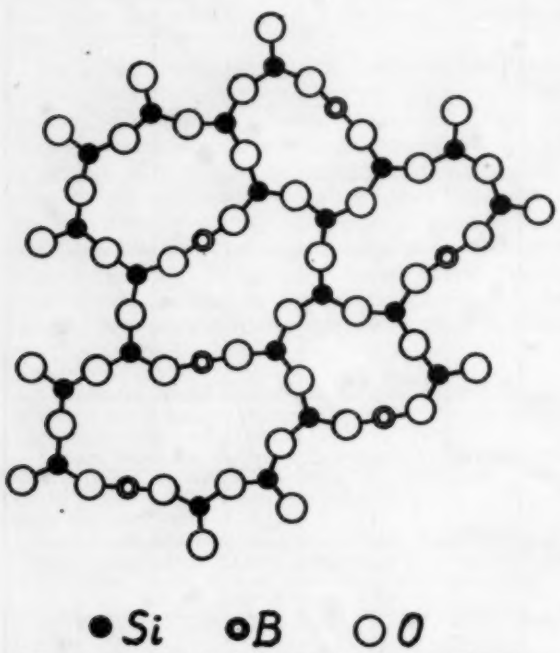

FIG. 3.—Schematic representation in two dimensions of the structure of boric oxide-silica glass. To correspond to 2 dimensions, the silicons are shown bonded to 3 oxygens rather than 4 and the borons to 2 rather than 3 oxygens.

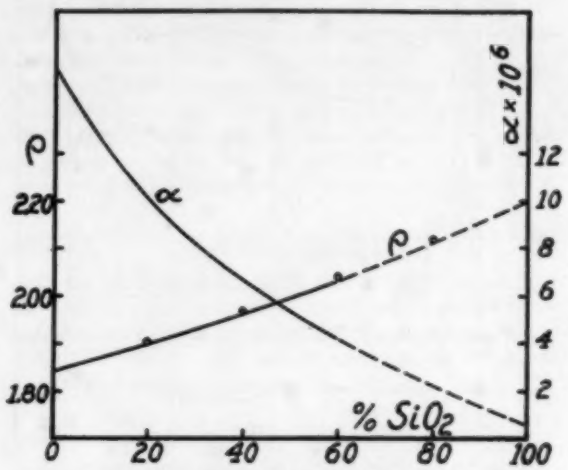

FIG. 4.—Density and coefficient of thermal expansion for boric oxide-silica glass.

The distribution curves indicate the following picture of a boric oxide-silica glass. Each silicon is tetrahedrally surrounded by 4 oxygens at a distance of 1.62 A, and each boron is triangularly surrounded by 3 oxygens at a distance of about 1.39 A. Each oxygen is bonded between 2 cations, *i.e.*, 2 silicons, 2 borons, or 1 silicon and 1 boron. The resulting network is a random network in which the scheme of bonding is so flexible that no feature in the structure necessarily repeats itself at regular intervals, and the material accordingly is noncrystalline. The structure of boric oxide-silica glass is represented schematically in two dimensions by Fig. 3. To correspond to two dimensions, the silicons are shown bonded to 3 rather than 4 oxygens, and the borons to 2 rather than 3 oxygens.

The distribution curve of Pyrex-brand chemical resistant glass is so similar to that of vitreous SiO_2 that the structures evidently are similar. Inasmuch as the glass is predominantly silica (81 SiO_2, 13 B_2O_3, 4 Na_2O, 2 Al_2O_3), this is not surprising. The distribution curve indicates that the silicons are in the usual tetrahedral coördination. The other constituents are present in amounts too small to allow any definite conclusions to be drawn from the distribution curve as to their coördination.

V. Physical Properties

The measured density[3] of boric oxide-silica glass is given by Fig. 4. The four circles indicate the density

[3] G. W. Morey, The Properties of Glass, p. 232. Reinhold Publishing Corp., New York, N. Y., 1938.

calculated on the basis of additivity of specific volumes, using 1.84 for B_2O_3 and 2.20 for SiO_2. The measured densities fall close to the values given by additivity. This is to be expected from the present picture of boric oxide-silica glass with the borons and silicons, each with the same coördination as in the component oxide glasses.

The measured values of the coefficient of thermal expansion[4] in the range 100° to 200°C are given on Fig. 4. The curve is shown dotted over the region for which no samples have been obtainable. Vitreous silica has a very small coefficient of expansion ($\alpha = 0.5 \times 10^{-6}$ per °C). The increase in expansion coefficient with increase in boric-oxide content may be understood in terms of the weaker bonding in a boric oxide-silica glass. The boron bonds itself to the surrounding atoms only in three directions rather than four, as in vitreous silica. The three bonds from a boron are in a plane, and the BO_3 triangle therefore is bonded to surrounding atoms only in two dimensions rather than three. This results in a looser structure which may expand more readily than the more rigidly bonded vitreous silica structure.

The softening of silica glass by the addition of boric oxide is a different process from the softening of silica by the addition of soda. In a boric oxide-silica glass, there is a continuous random network in which each silicon is bonded to 4 oxygens and each boron to 3 oxygens, each oxygen being bonded between 2 cations. There are no breaks in the network, and it is weaker than the network of silica because part of the cations are bonded in three directions only rather than in four. When soda is added to silica, however, part of the oxygens are bonded to 2 silicons and part are bonded to 1 silicon only. This produces breaks in the silicon-oxygen network, and the more of these breaks, the weaker the glass toward softening by temperature. Putting it in another way, the boron atom goes into the network as a poor substitute for the silicon atom, while the sodium ion goes into the network holes, and the extra oxygen introduced by the soda causes breaks in the silicon-oxygen network.

Pyrex-brand chemical resistant glass, with the approximate composition of 81 SiO_2, 13 B_2O_3, 4 Na_2O, 2 Al_2O_3, is essentially a boric oxide-silica glass. The X-ray results prove that the silicon is in tetrahedral coördination, but the quantities of the other three constituents present are too small to make any deduction from the X-ray study as to their bonding. In the feldspars, the Al atom is in the same tetrahedral coördination as the Si atom, and it is presumably in fourfold coördination in the Pyrex-brand chemical resistant glass. If the boron remains in threefold coördination and the Na^+ ions go into the network holes as in a soda-silica glass, the density may be calculated from the interpolated density of a soda-silica glass and the density of boric oxide. The value obtained is $\rho = 2.18$.

On the other hand, part of the boron atoms may be in tetrahedral coördination because of the extra oxygens introduced by the 4% of soda. Assuming all of the silicons and as many as possible of the borons to be in tetrahedral coördination and the remainder to be in threefold coördination so that each oxygen is bonded only to 2 principal cations (B or Si), the density is calculated to be $\rho = 2.22$. This is in better agreement with the measured value, 2.25. Although a great deal of reliance can not be placed upon calculations involving such small changes in density, it is reasonable and probable that at least part of the borons are in tetrahedral coördination in Pyrex-brand resistant glass.

VI. Thermal Expansion of Vitreous Silica

The coefficient of thermal expansion of vitreous silica is abnormally low compared with other glasses and with most crystalline solids. It is evident that the low expansion is a property of silica in the vitreous form,

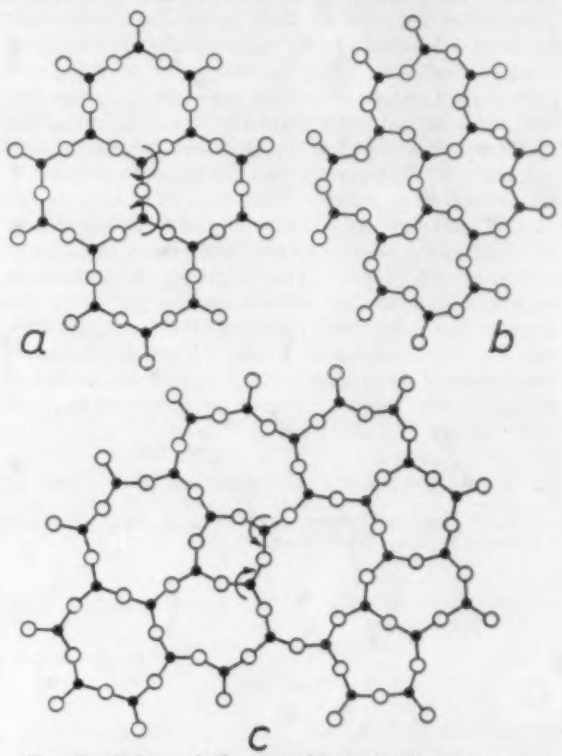

FIG. 5.—Schematic figure to illustrate thermal expansion in silica: (*a*) highly symmetrical crystalline form, (*b*) kinked form corresponding to crystalline forms of silica, and (*c*) representation of vitreous silica.

because the crystalline forms of silica have more nearly average values. There are two principal kinds of processes involved in thermal expansion, *viz.*, (1) change in interatomic distance of nearest neighbors and (2) change in quantities, such as bond angles which do not involve change in the interatomic distance of nearest neighbors. Because the silicon-oxygen bond is a strong bond, only a small change in silicon-oxygen distance would be expected, and the large expansion of the crystalline forms of silica therefore would be due to the second process.

Figure 5 (*a*) represents (schematically in two dimensions) a crystalline material with highly symmetrical structure; Fig. 5 (*b*) is obtained from 5 (*a*) by rotating

[4] G. W. Morey, *loc. cit.*, p. 277.

TABLE III
VOLUME COEFFICIENT OF EXPANSION AT 0°C*

Substance	$\frac{1}{v}\frac{dv}{dt} \times 10^6$
Quartz	33.6
Tridymite	73.0
Cristobalite	17.0
Vitreous SiO_2	1.1

each triangular group through a small angle, half of them rotating one way and half the other way. In the kinked structure of Fig. 5 (*b*), the two bonds to an oxygen are at an angle of about 150°, and this figure would represent schematically in two dimensions the structure of low quartz, low tridymite, or low cristobalite. The transition from (*a*) to (*b*) might be called a coöperative maneuver. Each triangular group must rotate in a definite way, alternate groups clockwise and counter clockwise. The possibility of carrying out such a coöperative maneuver depends upon the fact that the material has a regularly repeating crystalline structure, thus allowing the clockwise rotation of any one group to fit in exactly with the opposite rotation of the neighboring groups. This type of maneuver obviously can be carried out without involving any change in length of the silicon-oxygen bond or any breaking of silicon-oxygen bonds. The high-low transitions in quartz, tridymite, and cristobalite are just such maneuvers, involving small rotations all through the crystals but no breaking of bonds. A small change in orientation of the groups in Fig. 5 (*b*) produces a marked change in the volume. For an oxygen-bond angle of 150°, a change in this angle of 1° produces a fractional change in volume of $\Delta V/V = 0.0072$, which is the expansion of low quartz corresponding to a change in temperature of 210°C. If the oxygen-bond angle is temperature dependent, a change in this angle with change in temperature can readily account for the major part of the thermal expansion of the crystalline forms of silica.[5]

Figure 5 (*c*) represents schematically in two dimensions a silica glass. There is no repeating structure and no possibility of a systematic series of rotations. If an attempt is made at any point to decrease the oxygen-bond angle by opposite rotations of the neighboring triangular groups, the angle is increased for some other oxygens. The very "randomness" of the glass structure precludes the possibility of a marked change in volume through rotations without change in silicon-oxygen bond distance.

From this point of view, the small coefficient of expansion of vitreous silica is due to the fact that in the continuous random network a change of volume can come only from change in the silicon-oxygen distance. The silicon-oxygen bond is such a strong one that any such change will be small. The much larger expansion of the crystalline forms of silica results mainly from the coöperative rotations possible in a crystalline network, producing large changes of volume without appreciable change in the silicon-oxygen distance. Although this explanation probably is not the whole story, it suggests at least a simple atomic explanation for the very small expansion of silica in the vitreous form as contrasted with the much larger expansion of the crystalline forms of silica.

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* R. B. Sosman, Properties of Silica, p. 362. Chemical Catalog Co., Inc., New York, N. Y.

[5] The importance of a change in the oxygen-bond angle in determining the expansion of the crystalline forms of silica has been pointed out by H. D. Megaw, "Thermal Expansion of Crystals in Relation to Their Structure," *Z. Krist.*, **100**, 58 (1938).

BERYLLIUM OXIDE: I*

By H. E. White and R. M. Shremp

Abstract

This interesting and unusual material forms few mineralogical combinations, although many binary and some ternary diagrams have been plotted. The apparent stable crystalline formation at relatively low temperature has been confirmed by specific-gravity determinations on the oxide fired at different temperatures and on the electrically fused oxide, both by the writers and others. The thermal expansion of the electrically fused beryllium oxide and of bars of the oxide fired at lower temperatures is also very close. The electrical conductivity is higher than that for magnesia and alumina. The thermal conductivity appears to be greater than that of alumina and zircon. The hardness is 9.

I. Introduction

The properties of beryllium oxide are strength, purity, hardness, high electrical resistivity and relatively high thermal conductivity in the crystalline state, the ability to exist in the crystalline state over a long temperature range, and general thermal chemical inactivity.

Little work has been done on this oxide, and what has been done was usually on impure material because only recently has the pure material been available.

II. Experimental Work

A study of some exceptionally pure beryllium oxide† was made by the writers. The following analysis was determined:

	(%)
Fe_2O_3	0.02
SiO_2	.02
Al_2O_3	.004
CaO	.00
SO_4	.00

In addition, two determinations for total BeO content gave BeO 100.3% and 99.7%, respectively, which shows that the oxide is of the highest quality.

This material was pulverized, mixed with a small amount of dextrine, pressed into bars, and fired, one set at cone 18 and one at cone 33.

Bars were also made from some electrically fused oxide. This oxide was crushed, roasted in an oxidizing atmosphere, and washed in acid to remove the carbide‡; from the specific-gravity data and photomicrographs, however, there is evidence that some such impurity still remained.

The original chemical analysis of the electrically fused material was BeO 87.02, Be_2C 12.32, free C 0.47, Fe_2O_3 0.11, and SiO_2 0.08%. The analysis was made after removing free iron with a magnet.

Table I

Firing temp. (°C)	Specific gravity
	3.0*
	3.02†
725	2.876‡
800	2.86‡
875	2.926‡
1100	3.09‡
	3.04‡
1200	3.01‡
Electrically fused	3.025‡

* References (43), (40), (23).
† Reference (13).
‡ Reference (10).

Specific-gravity determinations were made on a number of samples by the authors. The method used was essentially the A.S.T.M. pycnometer method. The results are shown in Table II.

Table II

		Specific gravity
Raw oxide reignited at 930°C		2.983 (from roaster operating at 1400°C)
Expansion bar	cone 18	3.017
	cone 33	3.004
" "	electrically fused	2.951

Inasmuch as the electrically fused material was contaminated with a high percentage of beryllium carbide, the density of which is 1.90,** the determination for this material (Table II) may be accounted for. It was not possible to free the electrically fused material completely from the carbide.

III. Thermal Expansion

Navias (according to a communication from G. E. Merritt, Bureau of Standards, who gives a preliminary finding)[23] gives 7.5×10^{-6} (25° to 425°C) as the coefficient of thermal expansion. Braekken and Jore[5] give 0.5×10^{-5} with 50°C as the coefficient.

Thermal-expansion measurements were made by the authors. The apparatus used is essentially as described in the American Ceramic Society Standards Report[42] and also by White.[33]

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 31, 1938 (Refractories Division). Received March 19, 1938; revised copy received August 22, 1938.

Data on the thermal conductivity of BeO will be published later as Part II in the *Bulletin of the American Ceramic Society*.

Note: Numbered footnote references throughout this paper refer to the Bibliography references, p. 188.

† Supplied by the Brush Beryllium Co.; the analyses were also made by this Company.

‡ It has since been ascertained that beryllium carbide is practically unaffected by acid.

** C. B. Sawyer, Brush Beryllium Co., private communication.

The physical properties of the test bars are given in Table III.

TABLE III

Cone	Porosity (%)	Bulk density (g./cc.)	Apparent specific gravity
18	37.7	2.015	3.230
33	31.7	2.142	3.135
Electrically fused (refired at cone 33)	46.6	1.753	3.290

Austin* has permitted the authors to include data he obtained on the same lot of electrically fused BeO used in this study. Austin used an interferometer for his measurements and his curve coincides with those of Braekken and Jore[6] and Merritt.[23]

Austin also observed that the three specimens which he examined did not behave alike; apparently there was some preferred orientation in the pieces, and the anisotropic expansion appeared in different specimens.

The thermal expansion is lower than corundum and periclase, but compared to Heindl's work,[12] it is above zircon, silicon carbide, and mullite.

IV. Petrographic Data

(1) Raw Beryllium Oxide

This material (from a roaster operating at about 1400°C) is made up of two types of crystals. One type is elongated and needle-shaped, and the crystals have a tendency to form in clusters. They form in no definite pattern; they are sharply birefringent; and they have indices of 1.71 to 1.74.

* J. B. Austin, United States Steel Corporation, private communication.

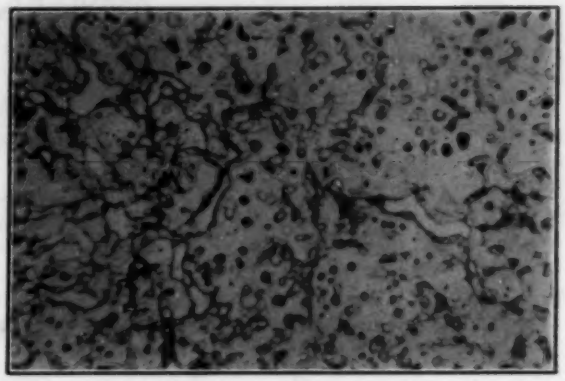

FIG. 1.—Electric induction fused BeO (100×, plain light).

The other type is composed of very small crystallites, and they also occur in tight clusters with an occasional needle crystal in the same cluster. Their index of refraction, when massed tightly together, is slightly lower than the other type, *i.e.*, about 1.69 or 1.70.

The usual impurities occur in this material, such as the brown and black opaque material and a few (rare) isotropic angular particles which look like glass.

(2) Fired Beryllium Oxide

Both samples (fired to cones 33 and 18) are identical; both are definitely crystalline, with indices of 1.71 to 1.74 and high birefringence. The crystals are uniaxial and optically positive and are so small that it is necessary to use an oil immersion lens. Each individual BeO crystal seems very clear, but there is a dark opaque film covering some of the conglomerate pieces. Most of

TABLE IV

LINEAR THERMAL EXPANSION OF BERYLLIUM OXIDE

Temp. °C	Beryllium oxide Fired to cone 18		Beryllium oxide Fired to cone 33		Electrically fused material refired to cone 33		Dilatometric method on electrically fused material*	
	K × 10^{-6}	Expansion (%)	K × 10^{-6}	Expansion (%)	K × 10^{-6}	Expansion (%)	K × 10^{-6}	Expansion (%)
25	0	0	0	0	0	0	0	0
50	4.92	0.0123	4.80	0.0120	4.80	0.0120	5.00	0.0125
100	5.47	.0409	5.42	.0406	5.35	.0401	5.40	.0405
150	5.72	.072	5.65	.070	5.61	.070	5.75	.0718
200	6.08	.107	5.98	.105	6.00	.105	6.00	.1050
250	6.45	.145	6.39	.144	6.32	.142	6.40	.1440
300	6.65	.183	6.60	.182	6.55	.180		
350	6.90	.224	6.83	.222	6.77	.220	7.00	.227
400	7.20	.270	7.08	.266	7.04	.264	7.25 (425°)	.272
450	7.28	.309	7.23	.307	7.21	.306	7.35	.294
500	7.40	.352	7.39	.351	7.37	.350		
550	7.62	.400	7.57	.397	7.52	.394		
600	7.82	.450	7.74	.445	7.67	.441		
650	7.97	.497	7.88	.492	7.80	.487		
700	8.13	.549	8.03	.542	7.98	.545		
750	8.26	.599	8.21	.595	8.18	.589		
800	8.42	.653	8.38	.650	8.28	.637		
850	8.58	.708	8.53	.708	8.44	.692		
900	8.65	.757	8.61	.757	8.62	.750		
950	8.77	.811	8.73	.806	8.70	.805		
1000	8.90	.867	8.89	.866	8.85	.861		

* J. B. Austin, private communication.

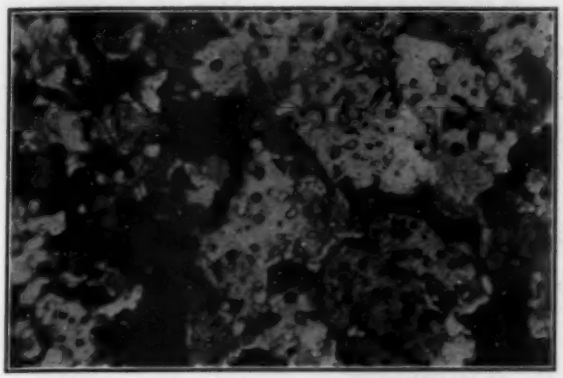

FIG. 2.—Electric induction fused BeO (100×, crossed Nicols).

these dark pieces have the same index, indicating that there must be BeO underneath.

V. Electrically Fused Beryllium Oxide

This sample of BeO, electrically fused, was extremely hard Its crystal faces were coated with what appeared to be iron oxide; it was uniaxial positive, with an index of 1.72 in thin sections. On thicker sections, N_o is slightly lower than 1.72 and N_e is slightly higher. There are many minute inclusions which have a lower index of refraction than the BeO.

Figures 1 and 2 were made from pure BeO, fused as part of a lining in an induction furnace.

Winchell[55] gives data for BeO as follows: hexagonal with $C = 1.63$; crystals prismatic with distinct $10\bar{1}0$ cleavage; $H = 9$, $g = 3$; insoluble in acid; uniaxial positive with $N_o = 1.719$, $N_e = 1.7333$, $N_e - N_o = 0.014$; color, white; recently found in nature and named "bromellite."

VI. Discussion of Results

The linear thermal-expansion curve (Fig. 3) checks fairly well with previous known data and, as far as the authors have been able to ascertain, it is the only curve on this material in the literature.

There is little difference between the curve for the electrically fused material and that fired above cone 18. Undoubtedly, the same crystal phase occurs.

The specific-gravity determinations are also in close agreement with previous work.

VII. Uses of Beryllium Oxide

Beryllium oxide was first used chiefly in the gas-mantle industry; about $^1/_2$ to 1% of beryllium nitrate was used in the mixture with which the mantles were impregnated.[39] Thomson[45] used a mixture of 100 parts of powdered beryllia to 1 part of colloidal beryllia and about 0.1% of free acid for crucibles and other fireproof vessels. More recently, BeO has been used as filament supports and spacers in vacuum tubes.*

One of the early metallurgical uses of the oxide was for radiation shields for vacuum fusion apparatus. In using BeO for this purpose, Chipman† found it necessary to sinter the material around 1700°C before forming in order to overcome the initial shrinkage. The oxide was crushed to pass a 60-mesh screen, and the tube formed from the oxide was slightly moistened with water. The moist oxide was packed around a paper mailing tube inside a slightly larger graphite cylinder. The mold and tube were dried overnight at about 100°C and then fired by induction at about 1700°C. Similarly, standard-size pressed brick and some special shapes have been made, but a removable mold was used, and the material was fired to high temperatures. These are used in high temperature electric furnace linings. They may vary in bulk density from 1.42 to 2.09, although the raw beryllium oxide from which they are made has a density of 3.02.

Trinks[46] describes a furnace which was developed after twenty-five years of experimentation by Paul Schwarzkopf. This furnace operates by means of molybdenum resistors and successfully withstands temperatures of 3000°F. The resistors are protected chiefly by the beryllium oxide which, even at high temperatures, reacts but slowly with molybdenum. Trinks has operated one of these furnaces up to 2950°F.

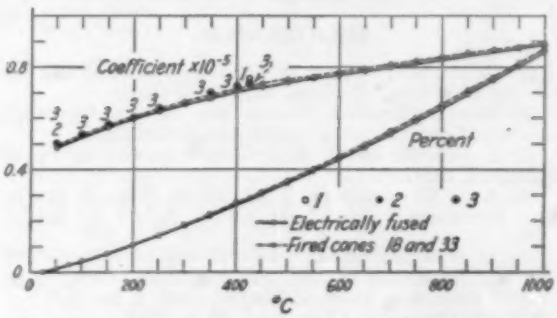

FIG. 3.—Linear thermal expansion of beryllium oxide. No. 1 (G. E. Merritt, *Trans. Amer. Electrochem. Soc.*, 50, 165–75 (1926)); No. 2 (see H. Braekken and O. Jore, Bibliography reference (5)); No. 3 (J. B. Austin, personal communication).

VIII. General Conclusions

In 1924, beryl production in the entire world was said to be not more than ten tons.[48] Sawyer[38] states that the supply of beryl continues to develop satisfactorily. He has been active in commercializing beryllium continuously since 1921, and he compares the early one-half ton orders for beryl (placed with some difficulty) to the present multiple-carload shipments.

More beryl is now available than the industry is consuming, although the supply is by no means limitless. Probably 500 tons of beryl are used yearly in the United States, and there is two or three times this amount available. More than one half of the beryl is imported from India and South America. Nowhere in the United States‡ is beryl known to occur in sufficient concentration to be mined alone; *e.g.*, in a Colorado mine, 50

* C. B. Sawyer, private communication.

† John Chipman, Massachusetts Institute of Technology, private communication.

‡ The present price is $48.00 per ton of 12% beryllium oxide (f.o.b. Philadelphia).

tons of feldspar are produced to one ton of beryl. Other mines, as those in the Black Hills, may produce valuable lithium ores. Practically all United States mines operate only on relatively large beryl crystals capable of easy hand-sorting.

Beryllium[3] is said to occur in the earth's crust in the amount of 0.0005%, and in this respect it lies between tin and arsenic in abundance.

The Bureau of Mines[26] has reviewed the facts regarding beryllium, giving a description and the properties, uses, history, and prices. This work was published in 1929 and is rapidly becoming out of date.

It seems evident that beryllium is entirely different from most other ceramic minerals. Here is a substance whose physical properties are constant over a range of more than 1000°C (from 1500° to 2570°C). It may be bonded without added impurities and may be so fabricated as to be machinable. The high cost of producing beryllium oxide in small quantities seems to be the only stumbling block inasmuch as other difficulties in production seem to have been overcome.

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CRISTOBALITE FORMATION AS A FACTOR IN FREEZING OF PYROMETRIC CONES*

By Paul Laurens Smith

Abstract

Studies were made of the thermal expansion, X-ray pattern, and fusion behavior of cones 7 and 8 "frozen" in a commercial kiln. Similar studies were made on specimens heat-treated in the laboratory, and it is shown that the characteristics of a "frozen" cone may be produced in cones 7 and 8 by proper heat treatment. Evidence is presented which indicates that freezing is due at least in part to the formation of cristobalite by devitrification.

I. Introduction

Pyrometric cones are known to differ from temperature-measuring instruments, such as pyrometers, in that the cones measure some function of time and temperature combined (ordinarily called heatwork) rather than of temperature alone. Cones, for this reason, are particularly useful in ceramic firing operations.

The successful performance of a pyrometric cone depends upon the formation of a liquid in the cone at a certain temperature. As the temperature increases, this liquid increases in amount and decreases in viscosity until the cone finally bends over under its own weight.

Under certain firing conditions, cones sometimes fail to deform at the proper temperature, although they will deform at a higher temperature. This behavior is called "freezing." The existence of freezing has been recognized for some time, and the problem has been studied before. Practical solutions were found upon two occasions.

The purpose of the present study was to determine the action of the various factors which affect freezing and to explain the mechanism of the freezing process. Inasmuch as the raw materials, *viz.*, whiting, clay, feldspar, and flint, which make up the particular cone series studied in this investigation, are the same as those used in whiteware, the reactions in these cones are similar to the reactions taking place in whiteware. The results obtained in this work therefore may be of general interest.

The first practical solution for the problem of cone freezing was found in 1928 by Henderson and Caldwell.[1] They corrected the freezing of cones 9 and 10 by adding talc to the raw batch.

Freezing in cones 6, 7, and 8 was studied more recently by Rea and Shaw,[2] who found that freezing

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The problem was studied under a Fellowship of the Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio (1935 to 1937) at the Department of Ceramics, Pennsylvania State College, State College, Pa.

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could be corrected by changing the composition of the raw batch by a partial substitution of soda feldspar for potash feldspar. They also noted that freezing occurs chiefly in coal-fired periodic kilns, where the cones are subjected to various gases as well as to an irregular heating rate.

II. Experimental

In the present investigation, the problem was studied by making various tests (1) on cones fired in a commercial kiln and (2) on raw cone batches which had been given well-defined heat treatments in laboratory experiments. These tests included (1) X-ray and microscopic examination, (2) thermal-expansion measurements, (3) temperature-deformation tests, and (4) indicator tests to detect glass formation.

III. Apparatus and Methods

The source of the X-radiation used to obtain the X-ray powder patterns was a Ksanda gas-type tube with a copper target. Operating at a 25-kilovolt potential and a 10-milliampere current, a 6-hour exposure was necessary. The samples were ground and coated on a copper wire whose pattern served to calibrate the film; the patterns obtained were compared with patterns of known pure materials.

The apparatus used in the thermal-expansion measurements consisted of a standard-type dial with a quartz rod and tube; the smallest scale division on the dial was $^1/_{10,000}$ inch. The quartz tube of the expansion apparatus was placed in a Nichrome-wound furnace with manual control. The specimens for the thermal-expansion measurements were cut either from standard cones or from prepared cylindrical billets, $^1/_2$ inch in diameter. In either case, the length was approximately 2 inches. A heating rate of 3°C per minute was used in the thermal-expansion measurements.

The indicators used to detect glass formation consisted of both uranium and cobalt compounds.* Uranium compounds fluoresce under the action of ultra-violet light only when the uranyl group is present. The glass phase, which would be expected to be formed here, would form such uranyl groups, whereas the crystalline phases would not. Cobalt compounds give a characteristic dark blue color to the glass phase due to the cobalt ion.

The cobalt test was found to give better results and was used exclusively in the later investigations. Cobalt was added to the batch as an alcoholic solution of $CoCl_2 \cdot 6H_2O$ in such amounts that its concentration in the final batch was slightly less than 1%. This indicator was mixed with the raw batch before the cylindrical billets were pressed. The billets were fired and examined for color, the depth and amount of color being taken as measure of the amount of glass present. In certain cases, thermal-expansion measurements were made on the same cylindrical specimens.

This glass indicator was used to determine the comparative behavior of the freezing and nonfreezing cone 8 batches. The "nonfreezing" cone 8 refers to the cone batch developed by Rea and Shaw, which contains a soda-feldspar addition rather than only potash feldspar. Similarly, the cobalt was added to batches with one or more of the constituents omitted, while maintaining the proportion of the remaining materials at the same values as a cone 8 batch. This was done to determine the components responsible for early fusing.

Blanks of Zettlitz kaolin mixed with the cobalt solution were fired and examined to ascertain whether or not the blue color might be due to a blue cobalt aluminate. These blanks developed only a very pale blue color, far different from the dark blue developed in the cones.

A comparison of the deformation behavior of the variously heat-treated cones was made by the usual cone deformation method. The cones used were about $1^1/_2$ inches in length.

The heat treatments of the specimens were carried out either in platinum-wound or Globar electric furnaces. Temperatures were measured with a Pt-Rh thermocouple which had been checked with a similar couple calibrated at the National Bureau of Standards.

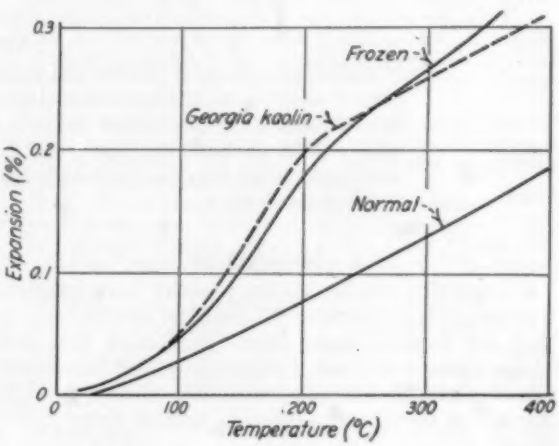

FIG. 1.

The specimens cut from cones and the billets mentioned previously were used in the heat treatments. Different heating schedules were investigated. The heat treatment which was found to be the most successful to produce specimens similar to frozen cones as they occur in commercial practice was (1) to heat the specimen at a comparatively high temperature (from 1100° to 1180° for cone 8) for several hours, (2) to lower the temperature 50° to 100°C, and (3) to hold for 10 hours. The particular values of time and temperature chosen are not so important, but the first heating should be sufficient to develop a fair amount of glass. This heat treatment is referred to hereafter as the "freezing" heat treatment.

* These tests were developed by Woldemar Weyl of The Pennsylvania State College. Dr. Weyl used this method to investigate the action of B_2O_3 in glass batches.

IV. Results

Several specimens of cones 7, 8, and 11 which had been frozen in a commercial kiln were studied. Experimental heat treatments were made in the laboratory on cones 7 and 8. Inasmuch as the results of these tests were similar, only those made on cone 8 will be given here.

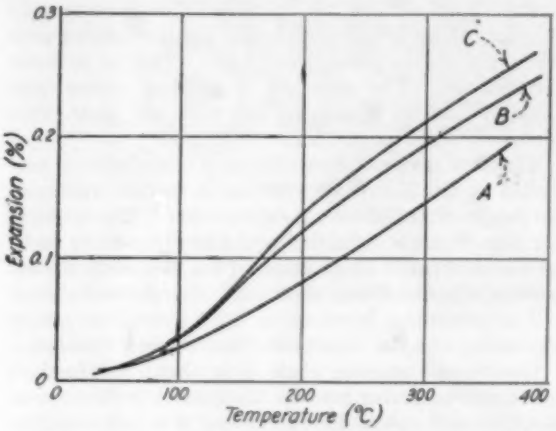

FIG. 2.—Cone 8 heat-treated 10 hours at 1180°C followed by A = 0 hour, B = 20 hr., and C = 60 hr., all at 1090°C.

A microscopic examination of fired cones had been made by Rea and Shaw,[2] who reported that the glass phase in the thin section of a frozen cone is more turbid than the glass of the normally fired cone. A study of thin sections of cones made in the present investigation failed to reveal any additional data on the cause of freezing.

The X-ray studies were more successful, although the results were not entirely conclusive. Certain lines in the pattern of a frozen cone were found to be more intense than the corresponding lines in the patterns of a cone showing normal deformation. These lines coincided with lines in the standard pattern of cristobalite. There were indications that some cristobalite is present in any fired cone but that there is decidedly more of this material in a "frozen" cone than in one fired normally.

The thermal-expansion measurements were made to gather further evidence on the nature of the new solid phase.

The results of these tests are shown in Fig. 1. The curve marked "frozen" represents the expansion of a cone frozen in a commercial kiln; that marked normal, the expansion of a cone which showed normal deformation. These curves are typical of frozen and normal cones. The high rate of expansion between 100° and 200°C occurred in all of the frozen cones that were examined. The dotted line (Fig. 1) is the thermal-expansion curve for a Georgia kaolin, which shows a similar high rate of expansion. This curve is taken from a study of kaolins by Heindl, Pendergast, and Mong.[3] These authors showed that the expansion effect in the kaolin was due to cristobalite, and the assumption here is that cristobalite is the cause of the similar effect in the frozen cone. The high rate of expansion of the frozen cones studied is believed to be representative of frozen cones in general, but because of the small number examined it can not be said with certainty that the cristobalite expansion effect occurs in all frozen cones.

The results of the thermal-expansion tests on cone 8 specimens heated for 10 hours at 1180°C and then held for varying lengths of time at 1090°C are summarized in Fig. 2. Curve A represents a specimen heated 10 hours at only 1180°C; curve B represents a specimen heated 10 hours at 1180°C and held 20 hours at 1090°C. The specimen, represented by curve C, was given the same treatment as that for curve B except that the time at 1090°C was increased to 60 hours.

These curves show distinctly that the expansion effect increased with the length of time the specimens were held at the lower temperature. This behavior was found to be typical for cones 7 and 8 of the batches which "froze" in kilns.

When the time of heating at the higher temperature was varied (the time at the lower temperature being constant), the expansion effect increased with increasing time of heating at the higher temperature.

The heat-treated specimens, showing the expansion effect, were also found to be similar in X-ray pattern and deformation behavior to cones "frozen" under commercial conditions.

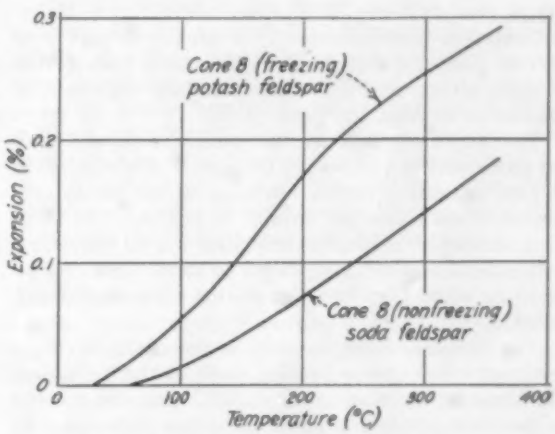

FIG. 3.—Comparison of freezing and nonfreezing cones 8 with same heat treatment.

The "nonfreezing" cone 8 was found to show normal deformation behavior under conditions of heat treatment sufficient to freeze the "freezing" cone 8.

The thermal-expansion measurements on a "freezing" cone 8 compared to a "nonfreezing" cone 8 given the same "freezing" heat treatment (held first at a high temperature, then at a lower temperature) are shown in Fig. 3. The high rate of expansion between 100° and 200°C may be seen clearly on the curve of the "freezing" cone; the curve for the expansion of the other cone is quite smooth and regular.

[3] R. A. Heindl, W. L. Pendergast, and L. E. Mong, "Kaolins: Effect of Firing Temperature on Some of Their Physical Properties," *Bur. Stand. Jour. Research*, **8** [2] 199–215 (1932); *Ceram. Abs.*, **11** [6] 387 (1932).

When cobalt was added (Section III, p. 190), specimens made from both batches became quite dark after heating at the high temperature, indicating the formation of much glass. After holding the specimens at a lower temperature, the cone with the soda feldspar remained quite dark and vitreous in appearance, and the cone containing the potash feldspar became much lighter in color and decidedly less glassy.

A mixture of lime, clay, and potash feldspar in the same proportions as a cone 8 batch showed no expansion effect and no change in color when given the "freezing" treatment.

A mixture of lime, flint, and potash feldspar showed marked effects in the same tests with similar heat treatment. In general, when flint was omitted from the batch, the freezing effects were absent.

The heat treatment used in both cases produced a marked freezing effect in a "freezing" cone 8 body.

Individual mixtures of two components were prepared in an effort to find which liquid formed first in the cones. These bodies contained the same proportions as a cone 8 batch and were fired after mixing with the cobalt solution. The amount of blue color developed was taken to be an indication of the amount of glass formed. These tests showed that the first liquid to form comes from the action of the lime on the feldspar.

V. Discussion

Frozen and normal cones from a commercial kiln have characteristic differences. The frozen cone has (1) a comparatively dull appearance, (2) a higher deformation temperature, (3) a greater intensity of certain lines coincident with cristobalite lines in the X-ray pattern, and (4) a characteristic high rate of expansion between 100° and 200°C.

The laboratory heat-treated specimens showed similar characteristics although, in general, slightly less in degree, indicating that a reference to the laboratory-prepared specimens as "frozen" is justified. In addition, compositions that were known not to freeze in a commercial periodic kiln, failed to show these characteristics when they were given the "freezing" treatment.

The increase of the amount of the expansion effect with increased time of heating, both at the higher and the lower temperature, indicates (1) that the amount of the new crystalline phase to appear increases with the length of time of low-temperature heat treatment (this is to be expected in a devitrification process) and (2) that the more glass formed before devitrification, the greater the amount of new crystalline material formed in a given time at the lower temperature. Both of these results point to freezing as a devitrification process.

A devitrification process is also indicated by the behavior of the specimens that contain cobalt oxide. Specimens of the freezing batch became light in color; those of the nonfreezing batch remained dark when the glassy cones were heat-treated at a lower temperature. The colorless crystalline phase presumably had an opacifying effect on the glass, thus rendering it lighter in color.

That the material crystallizing is cristobalite is suggested by the X-ray patterns and is further confirmed by the character of the expansion curve. The origin of the cristobalite is indicated by the fact that when treatments were made on quartz-free batches, both the expansion effect and the cobalt color change were absent.

The possibility, however, of other cyrstalline phases appearing with the cristobalite has not been eliminated.

No attempt has been made to develop a new method to eliminate freezing because the studies by Henderson and Caldwell and by Rea and Shaw demonstrated that this could be accomplished by changing the composition of the batch.

VI. Summary

Studies were made on the thermal expansion, X-ray pattern, and fusion behavior of cones 7 and 8 "frozen" in a commercial kiln; similar studies were made on specimens heat-treated in the laboratory. By proper heat treatment, the characteristics of a "frozen" cone were produced in cones 7 and 8.

Freezing seems to result from a devitrification process with the formation of cristobalite. The increased amount of crystalline material in the cone body causes it to deform at a temperature above normal, and this effect is called "freezing."

Acknowledgment

The author wishes to acknowledge the interest of N. W. Taylor throughout the course of the work. He is also indebted to W. Weyl for suggesting the cobalt test and for many helpful discussions. The experimental work on the effect of various components was carried out by G. A. Cleeves. Specimens of cones frozen in a commercial kiln and many of the materials for this investigation were obtained through the courtesy of Dr. Bole of the Edward Orton, Jr., Ceramic Foundation.

SOME PROPERTIES OF SEMISILICA BRICK*

By G. Bickley Remmey

Abstract

The most important differences between semisilica, super-duty, first-quality clay, and silica brick are shown by comparative tests. A new 24-hour deformation test is described which measures the rate of deformation of brick at various temperatures. First-quality clay brick are shown to have fairly rapid flow at temperatures as low as 2150°F, and super-duty brick at 2350°F; semisilica brick show a zero rate of deformation up to 2650°F. First-quality clay brick vitrify and spall at temperatures as low as 2300°F; under similar conditions, semisilica brick do not vitrify at much higher temperatures. Limitations in the use of semisilica brick are also discussed.

I. Introduction

There is a tendency today to study the properties of all of the different types of brick in order to select the brick best suited for each use. The siliceous clay brick of New Jersey have been studied from this viewpoint.

Inasmuch as the name "siliceous" might be confused with a lower grade brick and the name "New Jersey" is too indefinite, the brick referred to here will be called "semisilica" brick. The properties of this brick being compared in this study lie between those of a silica brick and a clay brick.

At least three different grades of semisilica brick have been developed, *viz.*, (1) a brick with maximum hot-load resistance, containing about 82% SiO_2; (2) a brick with a high resistance to thermal as well as vitreous spalling, containing about 75% SiO_2; and (3) a very hard brick with high resistance to abrasion and to certain slagging conditions.

This study deals mainly with the 82% SiO_2 grade.

II. Structure and Fusion Point

Figure 1(*A*) shows the high percentage of crystalline silica in the 82% semisilica brick, chiefly in the form of quartz. The surrounding material is the clay bond, which, if tested alone, has a P.C.E. of 33. If the silica is separated and tested alone, it also has a P.C.E. of 33. But if the brick which contains the combination of the two is tested, the P.C.E. drops to 28 or 29. This lower P.C.E. is caused by the Al_2O_3–SiO_2 eutectic, which starts to form at 2820°F and gradually destroys the original crystalline structure of the semisilica brick. The rate of this destruction is quite slow at 2900°F, enabling the semisilica brick to stand in a wall with a face temperature of 2900°F for a moderate length of time. The semisilica brick, however, is not usually recommended for prolonged use above 2800°F. At temperatures of 2800°F and lower, the eutectic shows no appreciable destructive effect on the brick. The highly crystalline body of the brick remains unchanged indefinitely except for the slow changing of quartz into cristobalite and tridymite, which results in a slight permanent expansion of the 82% semisilica brick and a negligible amount for the 75% semisilica brick.

When compared with clay brick, the lower P.C.E. of the semisilica brick may appear to be a serious limitation, but this is rarely the case inasmuch as 2800°F is usually a higher temperature than the practical limit for clay brick. At higher temperatures, silica brick or super-refractories are usually more suitable. In reference to boiler furnaces, the survey made by the Bureau of Mines in 1931[1] also showed that, with very few exceptions, 2800°F represents the highest wall temperature.

The semisilica-type brick therefore may be used in a very broad field with little risk of failure due to fusion.

III. Resistance to Deformation

An investigation of the causes of failure due to deformation under load at high temperatures of first-quality clay brick revealed that the brick fail because they act like very viscous liquids, *i.e.*, they become distorted slowly but continuously, permitting brickwork to sag gradually out of shape. A brick therefore must not have a continuous flow to be well suited for service under load at high temperatures. To study the characteristics of brick under load at high temperatures, the 24-hour load test was developed.

(1) Twenty-Four Hour Deformation Test

This test consists of heating a piece, 1 by 1.8 by 3.6 in., cut lengthwise from a brick, under the usual load of 25 lb. per sq. in. applied on its end. The heat is applied under load at a constant temperature for 24 hours while a deformation record is made. A curve is drawn showing the deformation plotted against time. The brick in this test is judged mainly by the rate of deformation per hour after equilibrium conditions (*i.e.*, when the curve becomes a straight line) have been obtained.

The first part of the test for the clay and semisilica brick represents the compression of the brick before the establishment of equilibrium conditions, and this part of the test is greatly dependent on the initial firing of the test specimen. When equilibrium condi-

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Refractories Division). Received March 15, 1939.

[1] R. A. Sherman, "Study of Refractory Service Conditions in Boiler Furnaces," *Bur. Mines Bull.*, No. 334, 144 pp. (1931).

tions have been reached, the composition and fabrication of the test specimen affect the rate of deformation.

After this test has been completed, the test specimens will show whether the tested brick have a tendency to vitrify at moderate temperatures. If the test is run at 2650°F, the first-quality clay brick usually vitrify to such an extent that if they are drawn from the furnace while hot and allowed to cool in air they will crack into several pieces. Superduty brick may not crack as do the first-quality clay brick, but they become vitrified to a great extent. Semisilica brick do not show evidence of increased vitrification.

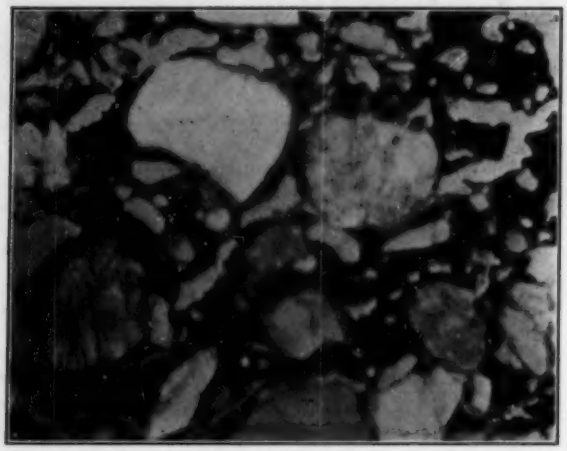

FIG. 1(*A*).—Thin section of 82% semisilica brick; crossed Nicols, gypsum plate.

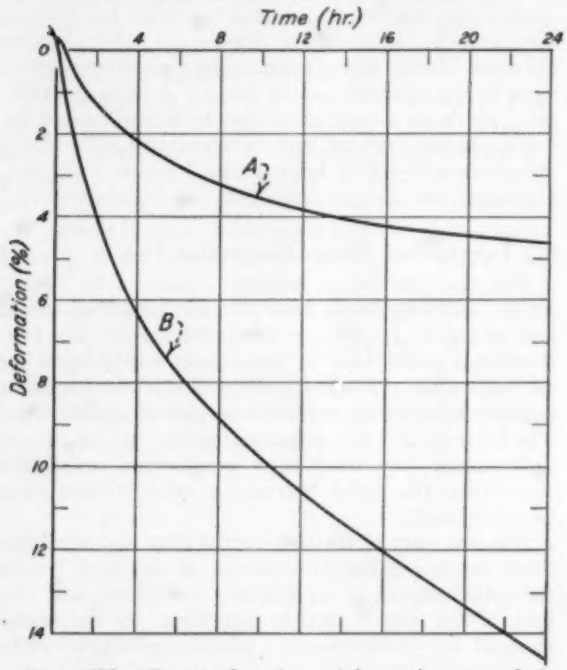

FIG. 1(*B*).—Twenty-four hour deformation test of the best and poorest of the ten different brands of first-quality clay brick. *Curve A*, dry-pressed first-quality clay brick A; *curve B*, coarse-ground first-quality clay brick B; temperature 2150°F.

(2) Deformation of Various Brick

When brick which do not contain a large percentage of crystalline minerals are held at a constant high temperature, they will first deform at a relatively rapid rate for several hours and then gradually assume a fairly constant rate of flow. Figure 1(*B*) shows a 24-hour deformation test run at 2150°F. The curves shown are of the best and the poorest of ten different brands of first-quality clay brick from Missouri, Kentucky, and Pennsylvania. The better one is a dry-pressed brick; the poorer one is a coarse-ground brick made to resist spalling.

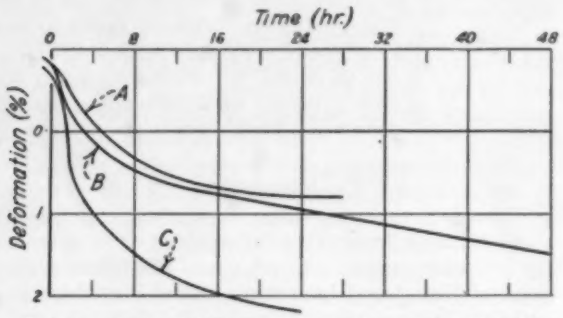

FIG. 2.—Forty-eight hour deformation test of high-fired 50% alumina brick. Rate of deformation the same during the last 38 hours of test. *Curve A*, 75% semisilica brick; *curve B*, 50% alumina brick (high fired); *curve C*, superduty brick; temperature 2350°F.

Figure 2 shows deformation-test curves of a high-fired 50% alumina brick, a superduty, and a 75% semisilica run at 2350°F. The rate of flow for the 50% alumina brick was so low that the test was continued for 48 hours to see whether or not any change in the rate of flow would occur. It may be seen that the flow continued at the same rate.

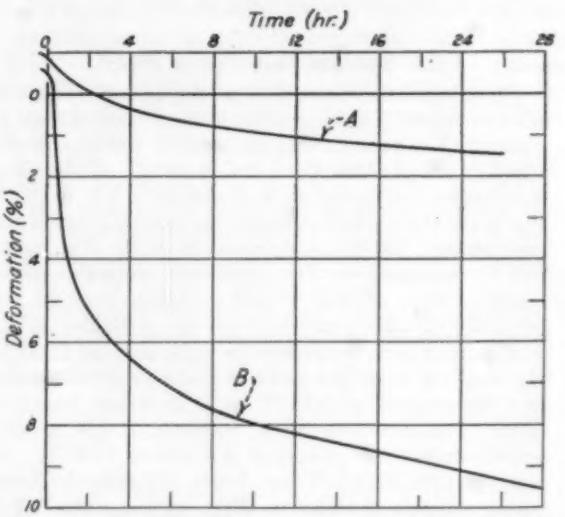

FIG. 3.—Twenty-four hour deformation test of 75% semisilica and first-quality clay brick. *Curve A*, 75% semisilica brick; *curve B*, first-quality clay brick A; temperature 2400°F.

The deformation curve of the 75% semisilica brick at 2400°F is shown in Fig. 3; this, of course, is not as high as the 82% brick, but it has a much higher resistance to mechanical spalling.

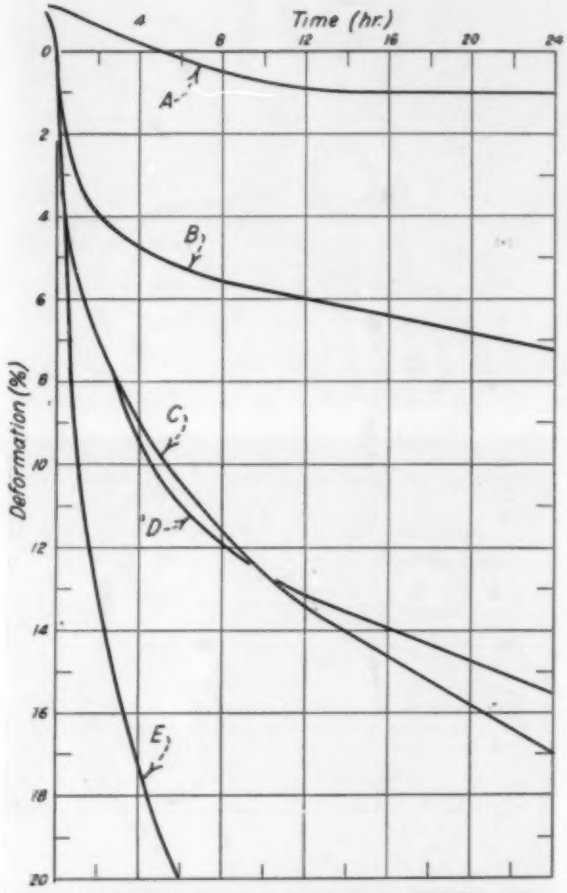

FIG. 4.—Twenty-four hour load test at 2650°F. Note zero rate of deformation of the semisilica brick. *Curve A*, 82% semisilica brick; *curve B*, superduty brick; *curve C*, first-quality clay brick F; *curve D*, first-quality clay brick A; *curve E*, first-quality clay brick D.

The curves in Fig. 4 are the result of a 24-hour load test at 2650°F and show how the 82% semisilica brick, after reaching equilibrium conditions, will have zero* compression per hour. Note the continuous deformation of the superduty and first-quality clay brick. This radical difference is made possible by the high percentage of crystalline material in the semisilica brick.

Superduty and higher alumina brick usually deform less than first-quality clay brick in the 24-hour deformation test, but they still have the same general property of continuous deformation.

One application of the high resistance to deformation of the semisilica brick is in insulated furnaces. Because they do not continuously deform up to 2650°F, they may be safely used in insulated furnaces operating at high temperatures.

Figure 5 shows an arch with a hot face temperature of 2750°F and insulation sufficiently thick to produce a temperature of 2350°F on the back of the brick. In such a case, the hotter quarter of the brick might be sufficiently hot to permit deformation, but the cooler three quarters of the brick would be below the deformation temperature of the 82% semisilica brick.

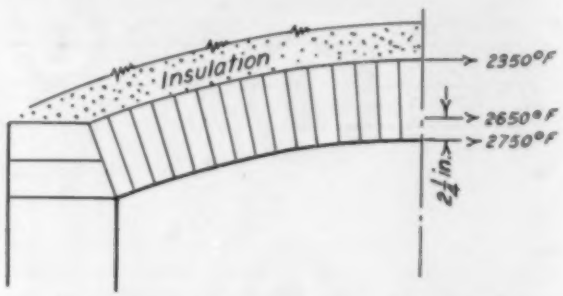

FIG. 5.—A 9-inch arch of brick with insulation; note three fourths of the brick is below 2650°F.

IV. Effect of Permanent Expansion on Deformation Test Curves of Semisilica Brick

The quartz in the 82% semisilica brick gradually converts into cristobalite and tridymite, resulting in a slight expansion (as explained in section II). The approximate effect of this expansion on the deformation curve of the 82% semisilica brick was next determined. Microscopic examination showed that, before testing, the brick contained between one third and one half quartz. This amount was considerably reduced after the first 24-hour test at 2650°F, showing that some expansion of the quartz had occurred which might have reduced the deformation curve slightly. In order to get a truer picture of the deformation of the 82% semisilica brick at high temperatures, two special deformation tests were run, one for 76 hours and another for 100 hours. Both test specimens were cut from the same brick. After the 76-hour run, the microscope showed only a small quantity of quartz; after the 100-hour run, there was no appreciable change in the quantity of quartz. The part of the curve between 76 and 100 hours consequently was not affected to a measurable extent by expansion, which indicates the true deformation curve for the semisilica brick at 2650°F. Figure 6 shows the 100-hour test on the semisilica brick and the 76-hour test on a superduty brick.

The semisilica brick (Fig. 6) shows (1) an expansion of about 0.2% during the 2500°F run; (2) after the bulk of the expansion has taken place during the 2500° and 2600°F runs, this brick does not quite come to equilibrium conditions in 24 hours but gradually reaches a zero rate of deformation during the last 9 hours of the test. These two facts seem to indicate that while the 82% semisilica brick appear to reach

* Zero rate of deformation is considered to be reached when the brick runs for six hours without showing any further deformation with an apparatus capable of showing a change of $^1/_{10}$%.

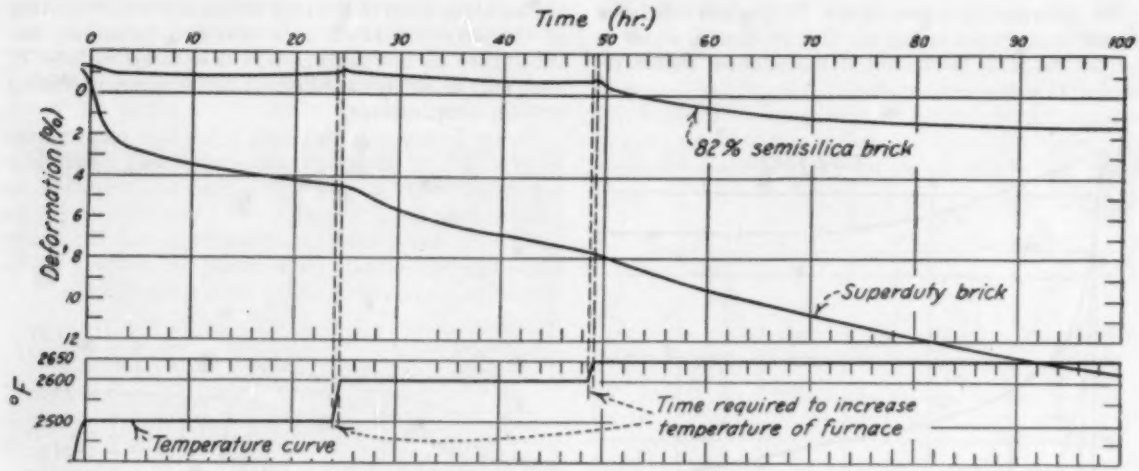

FIG. 6.—Deformation test of 76 and 100 hours.

equilibrium conditions in about 14 hours, in the regular 24-hour 2650°F deformation test, actual equilibrium requires a longer time. When true deformation was reached in the 100-hour test, the deformation was only 0.5% more than that in the 24-hour test. But the most important fact to be determined is whether or not the test brick will reach a zero rate of deformation. As long as both tests agree in this respect, it does not seem necessary to run tests longer than 24 hours for practical purposes.

V. Thermal Spalling

Resistance to thermal spalling (spalling without aid of vitrification) of the first-quality clay brick is very high. The resistance of the full silica brick is so low that special precautions must be taken every time they are heated and cooled. The resistance to thermal spalling of semisilica brick is lower than clay brick but much higher than silica brick.

Figure 7 shows the radical difference between the 82% semisilica brick and silica brick after 10 cycles in a panel-spalling test furnace without preheating. The 75% semisilica brick and the first-quality clay brick obviously would also look perfect in a similar test.

The 82% semisilica brick are used in many furnaces, such as ceramic kilns and reheating furnaces which are operated on monthly and weekly schedules. No special precaution is taken for heating and cooling. The 75% semisilica brick are more resistant to thermal spalling than the 82% brick, closely approaching the resistance of the first-quality clay brick. This type of brick performs successfully in furnaces, such as boiler furnaces which are heated and cooled frequently.

It should be understood, however, that if the prime cause of destruction of fire brick is thermal spalling, clay brick should serve longer than semisilica brick.

VI. Vitreous Spalling

Vitreous spalling (spalling caused by vitrification of the ends of the brick) is common in many furnaces

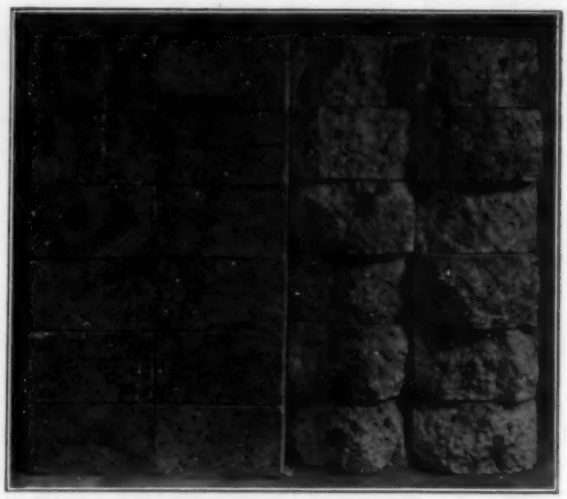

FIG. 7.—After 10 cycles in panel-spalling test without preheating: *left*, 82% semisilica brick; *right*, regular silica brick.

when first-quality clay brick are used. Higher temperatures, with the aid of fly-ash fusing on the wall, greatly speeds up the rate of vitrification. Silica brick do not vitrify under service conditions of clay brick, but their exceptionally low resistance to thermal shock makes them impracticable for use in furnaces which are frequently shut down. Because semisilica brick are enough like silica brick not to vitrify at temperatures under 2800°F and still have sufficient resistance to thermal shock, they meet with favor for use in furnaces where vitreous spalling is encountered.

A comparison of semisilica brick and a first-quality clay brick, taken from a furnace where the temperature was between 2600° and 2700°F most of the time, is shown in Figs. 8 and 9. Note how the slag from the fuel oil on the first-quality clay brick soaks in to a

considerable depth. This makes the face brittle and subject to spalling. The slag on the semisilica brick is confined to the outside surface, and the brick have not vitrified. This peculiar difference in the slag

FIG. 8.—Two first-quality clay brick after removal from furnace which operated between 2600° and 2700°F. The bottom brick has been ground off to show the deep slag penetration; note also the spalled ends.

reaction in these two types of brick is hard to explain. Norton,[2] who refers to a similar condition as "wetting the surface by slag," explains that when the slag wets the surface of the brick it is drawn by capillary attraction deep into the pores. If, however, the slag does not wet the surfaces, it lies harmless on the face of the brick.

The fact that semisilica brick are relatively dry and low in glass content at high furnace temperatures might be a factor. It is difficult to say how broadly this property of zero slag absorption might be applied. From experience in the use of semisilica brick, however, slag from all fuels appears to behave in a similar manner.

There has been a demand for a spalling test to show up this difference between the two brick. At the present time, such a test is impracticable because clay brick can not be made to vitrify in the short time required for a laboratory test unless abnormally high temperatures are used. This destroys the semisilica brick as explained under Fusion (section II). The present panel-spalling test, furthermore, does not put any slag on the face of the brick, which is a serious factor in the spalling of brick in service. Brick not only vitrify more readily when the slag soaks into them, but the composition of the end of the brick containing the slag is changed, causing it to spall much more easily. The problem, therefore, is to make the brick vitrify as they do in service. If this could be done, the thermal-shock part of the present panel tests should show up the true difference. Although a test of this type is impracticable for a laboratory, one has been made by placing the different types of brick in a kiln wall for a prolonged heat treatment instead of preheating them at 3000°F, as in the standard panel spalling test.

(1) Comparative Spalling Test on First-Quality Clay and Semisilica Brick

A dry-pressed flint clay brick with a P.C.E. of 32 to 33 and an 82% semisilica brick with a P.C.E. of 29 were used for this test. In place of the preheating part of the present spalling test, the two types of brick were laid up in the wall of a firebrick kiln. The maximum brick-face temperature reached about 2300°F, and the

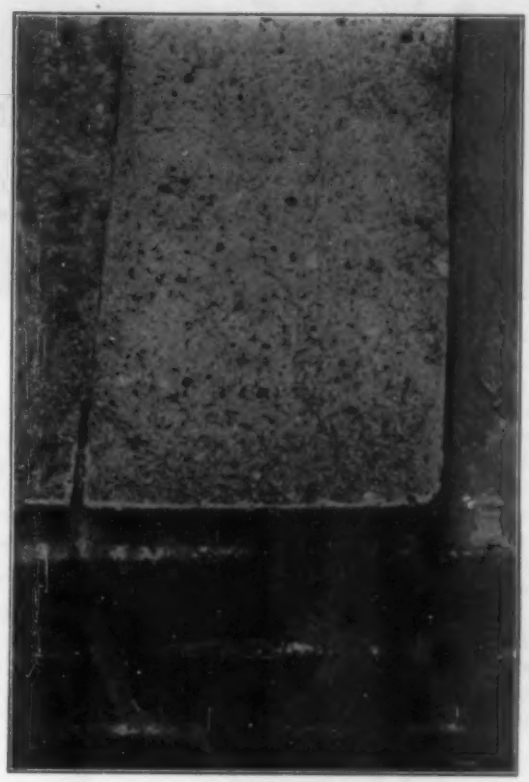

FIG. 9.—Looking down on section of brick removed from the same furnace referred to in Fig. 8. The top brick shows that the slag is confined to the surface.

brick were exposed to a moderate amount of fly-ash. The test brick were five feet above the coal-burning fireboxes. This place was selected to show that under these moderate conditions vitrification will take place in first-quality clay brick.

Figure 10 shows the appearance of these brick in the kiln wall after 50 firings of the kiln over a period of about $2^1/_2$ years. The temperature was in the vicinity of 2300°F for about 9 hours during each run. There is no slag on the clay brick in the upper part of Fig. 10, but it is thick enough to run on the semisilica brick below. The fly-ash that settled on the first-quality clay brick has soaked into them, but it has remained on the surface of the semisilica brick. The first-quality clay brick eventually will also become slagged, but not until

[2] F. H. Norton, Refractories. McGraw-Hill Book Co., 1931.

the hot ends become saturated, at which time they are likely to spall from the slightest thermal shock.

One of each of these brick, after it has been removed and ground off, is shown in Fig. 11. The dark, hard end of the clay brick on the top was caused by the slag soaking in. The depth to which the slag will penetrate

FIG. 10.—No. 1 clay brick above and 82% semisilica brick below, after 50 runs in a periodic kiln.

first-quality clay brick depends mainly on the temperature gradient through the brick and secondly on the properties of the slag. The slag penetrated this brick about $1^1/_2$ inches. In Fig. 8, where the temperature was between 2600° and 2700°F, the slag penetrated about $5^1/_2$ inches. The slag on the semisilica brick (Fig. 11) is kept on the surface as it was in Fig. 9, which was at a higher temperature.

To test this explanation that slag has penetrated the end of the first-quality clay brick and not the semisilica brick, a P.C.E. test was made on samples taken $^1/_2$ inch from the ends of each brick. The results are as follows:

First-quality clay brick	Cone No.
$^1/_2$ in. from heated end	31
$^1/_2$ in. from cool end	32–33
Semisilica brick	
$^1/_2$ in. from heated end	29
$^1/_2$ in. from cool end	29

Although the clay brick are not vitrified enough to spall in the kiln wall where the thermal shocks were very moderate, the two types of brick were removed and laid up in a panel of a panel-spalling test furnace.

The panel ready for test with the clay brick on the left is shown in Fig. 12. Because it was necessary to break the brick apart to remove them from the kiln wall, some of the slag-coated ends of the semisilica brick were damaged. This panel was given 10 cycles of spalling following the same procedure as the standard U. S. Navy spalling test.[3]

The brick after the test are shown in Fig. 13. The first-quality clay brick again are on the left. The radical difference in the spalling behavior of the two types of brick is apparent.

VII. Slags

Resistance to slag erosion, unlike resistance to deformation, is not a definite property. This is caused by the wide variations in slag composition, the quantity of slag running over the brickwork, and the radical

FIG. 11.—One of each of the brick from Fig. 10 after being removed and ground off.

difference in the chemical effect possible in a given slag when the temperature and furnace atmosphere are varied.

Experience with furnaces of the malleable-iron type, however, has shown that the slag at operating temperature usually dissolves the semisilica brick so rapidly that, in spite of this zero slag absorption

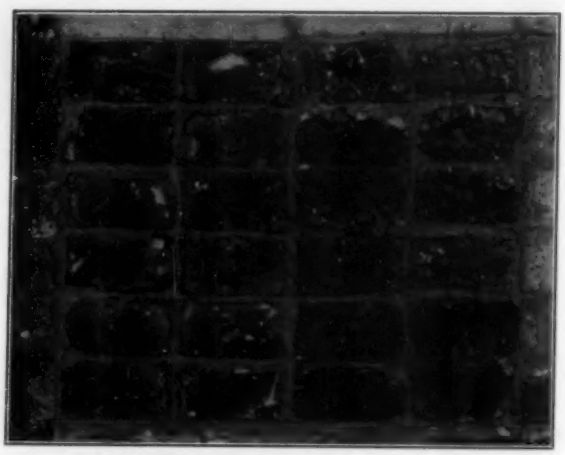

FIG. 12.—Some brick from Fig. 10 laid up in a panel ready for test; semisilica brick on right.

property (see Fig. 10), the brick are eroded much more rapidly than first-quality clay brick or the higher alumina brick. In other furnaces in which slag erosion is the major cause of failure, such as gray iron cupolas or water gas generators, the harder grade of semisilica brick stand the slag and gases better. In boiler furnaces operating at moderate temperatures, the semisilica brick are often preferred over first-quality clay

[3] U. S. Navy specification, 32-B-2-B, December 1, 1937.

brick. At the highest temperatures and under the most severe slagging conditions, however, first-quality clay brick and brick of higher alumina content usually serve better.

These statements might be explained by the fact that the ability of the semisilica brick to keep the slag on the surface at moderate temperatures is often more desirable than the slightly lower rate of solution of the first-quality clay brick. As temperatures increase,

FIG. 13.—Same brick as shown in Fig. 12 after 10 cycles in panel-spalling test.

however, the rate of solution of the semisilica brick usually increases faster than first-quality clay brick until a point is reached where the advantages of the semisilica brick would be offset. The temperature of this point varies with slag composition, quantity of slag flowing over the brick, and the atmosphere of the furnace.

Along the clinker line of many stoker-fired boiler furnaces, the quantity of slag flowing over the brick is so much higher than the rest of the furnace that it is often economical to use a super-refractory in this area; the semisilica brick should be well suited for the remainder of the setting.

VIII. Conclusions

The semisilica brick is a development of the old Jersey-type brick. It has been developed, however, to an entirely new standard of quality, and, in a sense, it is a new refractory product, possessing some properties which are impossible to match either in first-quality clay brick or silica brick. The most important advantages of the semisilica brick, compared to first-quality clay, are (1) the ability to resist deformation under load at high temperatures and (2) the resistance to vitreous spalling. When compared with regular silica brick, the advantage is that the resistance to thermal spalling is sufficiently high to permit its use as a clay brick.

As the properties of the semisilica brick become better known, further economies in the maintenance of many furnaces should be made possible.

New tests and specifications should be developed for semisilica brick. The writer's experience indicates that the 24-hour load test simulates service conditions and is well suited for testing semisilica-type brick. It will also show the tendency of a brick to vitrify. This test, in conjunction with a thermal spalling test (second part of present panel spalling test) and SiO_2 determination, might be used in making a suitable specification for semisilica brick.

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EFFECT OF ATMOSPHERIC EXPOSURE ON THE PROPERTIES OF UNFIRED CLAY BODIES*

By J. O. Everhart and R. Russell, Jr.

Abstract

The effect of storage conditions on the unfired properties of seven representative ceramic bodies is reported. These bodies were dried thoroughly and stored in desiccators, open air, and damp rooms for various periods of time. The effect of this treatment on volume, weight, and transverse and compressive strengths was observed. One surface clay showed complete loss of strength after a few hours of exposure in the open air. Other bodies showed less change, but all were affected to some degree. Bodies with low organic content may be restored approximately to their original condition by redrying; those high in organic content can not be restored.

I. Introduction

The investigation of this problem was instigated by the discussion of a problem in drying presented at a meeting of the Structural Clay Products Division of the Ohio Ceramic Industries Association. The particular problem was concerned with the peculiar behavior of a surface clay body during the latter stages of drying and before setting in the kiln. Experience indicated that if the ware was permitted to stand on the drying floor after the heat was turned off or if it remained in the kiln after setting an appreciable length of time before firing was commenced, a considerable amount of cracking resulted. The problem proved to be so interesting that the Engineering Experiment Station at The Ohio State University agreed to coöperate with the company operating the plant in a study of the cause and a possible remedy for the trouble. One of the authors of this paper spent some time during the summer of 1937 in the plant working on the problem, and the findings are presented herein together with laboratory investigations made at a later date on other bodies covering a range of ceramic products.

II. Plant Investigation

A glacial surface clay was used that was sufficiently weathered to be practically free from lime pebbles on the top portion of the deposit. The quantity of lime became excessive below approximately $3\frac{1}{2}$ or 4 feet, and only the top portion was used. Of this upper part, about 8 to 10 inches was a very dark top soil, obviously high in organic material. Below the top soil, the deposit was rather uniform and free of organic material or other impurities until the level of the lime pebbles was reached.

The clay, including the top soil, was dried in a rotary drier, ground, tempered, and formed into ware on a deairing machine. The ware was dried in slotted floor driers, common to the sewer-pipe and drain-tile industry. These driers were three stories in height and were heated by waste heat introduced below the bottom floor.

The following general observations on drying behavior were made: (1) cracking of the ware was more common in the larger sizes; (2) cracking occurred under two conditions, *viz.*, (*a*) when dry or nearly dry ware was exposed to air at atmospheric temperatures and (*b*) when dry or partially dry ware on an upper floor of the drier was exposed to moisture-laden air rising from green ware freshly set on a lower floor; and (3) ware from which part of the moisture had been removed absorbed moisture from the surrounding air in appreciable quantities when the relative humidity exceeded approximately 70%. The increase in weight owing to moisture absorption was always accompanied by a slight expansion and frequently by cracking.

The following plan of drying control was successful in reducing the amount of cracked ware: (1) ware was set in the kiln whenever possible as soon as drying was completed; (2) setting wet ware on a floor below either dry or partially dry ware was avoided whenever possible; and (3) the relative humidity of the air around partially dry ware was kept below 70% if possible; the practice of part (2) was helpful in accomplishing part (3).

Because it was not always possible to practice all of these methods of procedure, some cracking persisted.

It was thought that the large quantity of organic matter in the top soil might account for the tendency of the body to absorb moisture and expand under certain conditions. Pending laboratory tests, the top soil was discarded. Cracking was reduced immediately so as to be practically negligible even when dry ware was allowed to come in contact with humid air.

Since that date, the top soil has been consistently discarded and there has been practically no drier loss. Incidental to improvement in drying, the firing behavior also improved.

III. Laboratory Tests

Tests were conducted on the top soil, center of the bank, and an average mix of the entire workable bank (including top soil) from the plant where the trouble had been encountered.

Standard 1- by 1- by 6- inch bars were extruded by the stiff-mud process to study the effect of atmospheric exposure on strength. Longer bars (1 by 1 by 12 in.) were

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans La., March 30, 1938 (Materials and Equipment Division). Received January 21, 1939.

extruded for a study of the effect of atmospheric conditions on dimensions and weight.

The strength tests were made on bars dried 96 hours at 250°F, followed by storage either in open air or in a damp room for various time intervals. Data from these tests are given in Table I.

TABLE I

SURFACE CLAY

Method of storage		Modulus of rupture (lb./sq. in.)	Moisture absorbed (%)
Top soil			
As out of drier		1866	
Damp room (hr.)	3	288	0.90
	6	270	1.81
	9	220	2.37
Center of bank			
As out of drier		918	
Damp room (hr.)	3	725	0.68
	6	670	1.42
	9	640	1.54
Average of entire bank			
As out of drier		1765	
Damp room (hr.)	3	781	0.97
	6	205	1.75
	9	97	2.17
Mixture of center and bottom of bank			
As out of drier		1220	
Damp room (hr.)	4	270	
	8	204	
	16	154	
	24	97	
Open air (hr.)	24	574	
	48	395	
	68	340	

These data indicate a rapid decrease in strength upon exposure to moisture-laden air. The top soil apparently is affected to the greatest degree. Data for mixtures of the center and bottom clay are shown in Fig. 1.

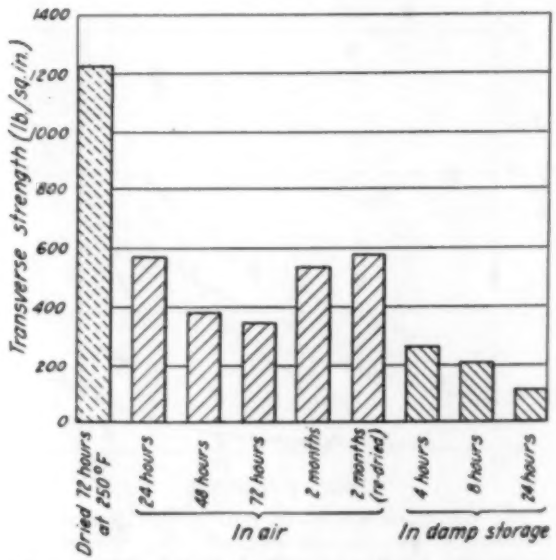

FIG. 1.—Effect of atmospheric and damp storage on strength of a surface clay body.

Bars, 12 inches long, were mounted horizontally on rollers with one end against a solid rest and the other against an Ames dial. They were thus exposed to the air on all four sides, and their behavior in changes in length compared with changes in atmospheric conditions could be observed. Their weight was also checked at periodic intervals. Temperature and relative humidity values were obtained at frequent time intervals coinciding with the time of reading length and weight values. These data are presented in Fig. 2, together with data obtained from a whiteware body under the same conditions.

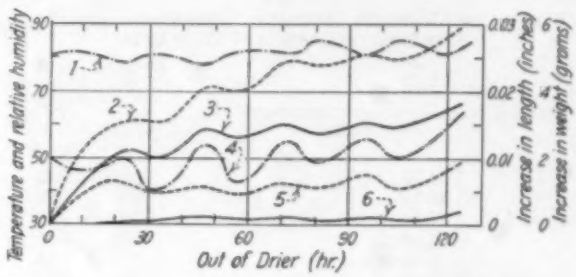

FIG. 2.—Behavior of unfired surface clay and dinnerware bodies upon exposure to atmosphere: (1) temperature °F; (2) weight of surface clay; (3) length of surface clay; (4) relative humidity; (5) weight of whiteware; (6) length of whiteware.

Following these tests, a series of tests was conducted on specimens made from Bedford shale, Lawrence clay, a semivitreous dinnerware body, and a sandy shale from the Cleveland district used for making paving brick. Each body was extruded in a 1- by 1-inch column. Test pieces from each body were subjected to various storage conditions. Specimens from the Cleveland shale and Lawrence clay bodies were broken in both transverse and compressive strength tests after storage. The other bodies were broken only in transverse strength tests. The results are given in Tables II, III, IV, and V.

TABLE II

EFFECT OF STORAGE CONDITIONS ON DRY TRANSVERSE STRENGTH OF A BEDFORD SHALE BODY

Storage condition (dried 72 hr. at 250°F before storage)		Modulus of rupture (lb./sq. in.)
No storage		405
Cooled in desiccator		412
In open air (hr.)	24	299
	48	235
	72	220
	72 (redried at 250°F)	346
Damp storage (hr.)	1	223
	4	130
	8	107
	24	80

TABLE III

EFFECT OF STORAGE CONDITIONS ON DRY TRANSVERSE STRENGTH OF A SEMIVITREOUS DINNERWARE BODY

Storage conditions (dried 72 hr. at 250°F before storage)		Modulus of rupture (lb./sq. in.)
No storage		520
Open air (days)	1	372
	1 (redried at 250°F)	536
	11	295
	11 (redried at 250°F)	493
	48	285
	48 (redried at 250°F)	480

TABLE IV

EFFECT OF VARIOUS STORAGE CONDITIONS ON DRY STRENGTH OF LAWRENCE CLAY BODY

Method of storage (dried 72 hr. at 250°F before storage)		Modulus of rupture (lb./sq. in.)	Compressive strength (lb./sq. in.)
No storage		715	878
Open air	24 hr.	704	803
	48 hr.	606	650
	72 hr.	706	711
	1 week	581	626
	1 month	407	654
Cooled in desiccator		685	862
100% humidity (hr.)	1	438	821
	2	417	616
	4	404	625
	8	374	577
	8 (redried at 250°F)	670	954
Open air	72 hr. (redried at 250°F)	717	784
	1 month (redried at 250°F)	675	843

TABLE V

EFFECT OF VARIOUS STORAGE CONDITIONS ON DRY STRENGTH OF CLEVELAND SHALE BODY

Method of storage (dried 72 hr. at 250°F before storage)		Modulus of rupture (lb./sq. in.)	Compressive strength (lb./sq. in.)
No storage		501	1122
Open air	24 hr.	465	1035
	48 hr.	452	868
	72 hr.	420	914
	1 week	429	754
	1 month	369	618
Cooled in desiccator		455	1050
100% humidity (hr.)	1	364	923
	2	343	852
	4	329	602
	8	313	588
	8 (redried at 250°F)	446	1230
Open air	72 hr. (redried at 250°F)	486	977
	1 month (redried at 250°F)	472	933

Because natural atmospheric conditions during the course of the investigation did not yield relative humidity above approximately 60%, a higher humidity was obtained by placing specimens in an air-tight container over solutions of various inorganic salts. A complete range of humidities from 40 to 100% was thus obtained. The behavior of the four bodies is shown in Figs. 3 and 4. From these data, absorption of moisture and change in length are seen to be nearly a direct function of the relative humidity of the surrounding atmosphere for humidities ranging from below 40% to approximately 70%. In atmospheres having humidity above 70%, the change in length and weight is increasingly great for each increment of change in humidity.

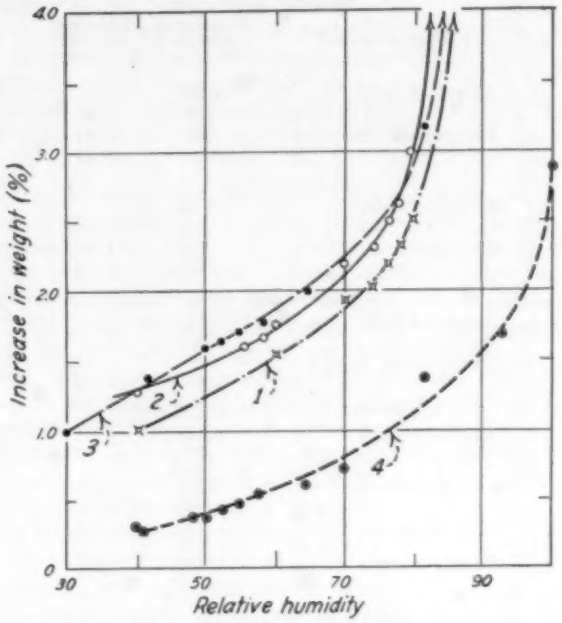

FIG. 3.—Relation between relative humidity of surrounding atmosphere and moisture absorbed by dry unfired specimens. *Curves:* (1) surface clay A, top soil; (2) surface clay A, entire bank; (3) surface clay B, entire bank; (4) semivitreous dinnerware body.

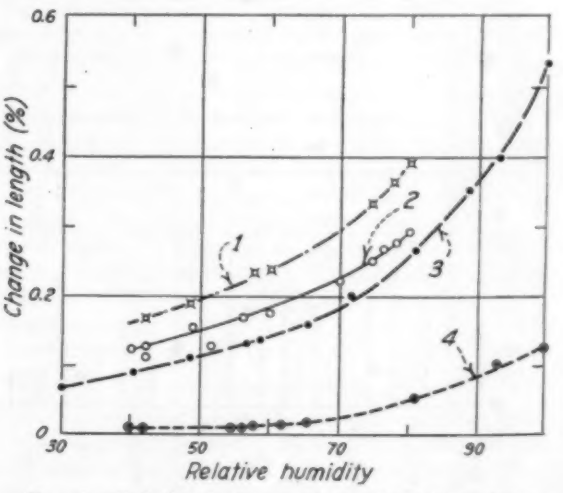

FIG. 4.—Relation between relative humidity of surrounding atmosphere and length of dry, unfired test specimens. *Curves:* (1) surface clay A, top soil; (2) surface clay A, entire bank; (3) surface clay B, entire bank; (4) semivitreous dinnerware body.

When the humidity was above 80%, the surface clays absorbed moisture so rapidly that they lost their form and became fluid.

IV. Summary

All of the bodies studied showed a decided loss of strength when exposed to air after drying.

They were affected most by conditions of high humidity. Exposure even for a short time to very "humid" air will result in a considerable loss of strength.

There is reason to believe that the presence of organic matter in the body increases the tendency for dry ware to absorb moisture and expand in doing so.

In most cases, the body may be returned to a condition approximating its original condition by redrying. The surface clays studied failed to return to their original state and remained in a weakened condition.

It is recommended that all ceramic bodies should be set in the kiln immediately after drying. This seems to be especially advisable for ware made from surface clays with a high organic content.

All bodies examined showed a direct change in weight and dimensions with change in atmospheric conditions.

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Columbus, Ohio

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June, 1939
18—6

Abrasives

Abrasives. V. L. Eardley-Wilmot. *Mineral Ind.*, **46**, 25 (1937).—A survey made of the production of abrasive materials during 1937 showed the following results: (*1*) *Industrial diamonds:* Over two thirds of the world diamond output was used for industrial purposes. Black diamonds (carbonado) were obtained from Bahia, Brazil. Bort, consisting mainly of stones unsuitable for gems, was produced in the Belgian Congo and South Africa. No industrial diamonds have been mined commercially in the U. S. since 1932 when 300 carats were obtained from a deposit in Arkansas. (*2*) *Corundum:* Northern Transvaal, S. Africa, was the main source of supply. The corundum, except for 141 out of 2470 tons, was shipped to the U. S. (*3*) *Emery:* The best emery was obtained in Greece and Asiatic Turkey. In general, this material consists of a mixture, in varying proportions, of corundum and magnetite, with the corundum replaced by spinel and other minerals in the cheaper grades. (*4*) *Garnet:* Except for a few tons from Spain, practically all garnet was mined in the U. S. and was used for coated paper and cloth abrasive. After concentration by gravity and magnetic separation methods, most of the garnet was heated to increase the capillarity of the grain. B.C.R.

Forging and rolling tool steels. Henry C. Bigge. *Metal Progress*, **34** [6] 665–70 (1938).—B. discusses ingot size, amount of reduction to finished bar, reheating practice, comparison of roll cogging and hammering, grinding of billets, descaling, use of atmospheres, and annealing practice. F.P.P.

Grinding papers and their manufacture. K. Dopp. *Oberflächentech.*, **16** [4] 33–34 (1939).—D. describes in detail the requirements for papers on which grinding materials are fastened and their manufacture and the means for sorting and binding the grinding material. Papers made with additions of bitumen have proved satisfactory. The thickness of the paper must conform to the coarseness of the grinding material (glass, pumice, silicon carbide, etc.). This material must be free of all impurities and fatty and oily traces. M.H.

Grinding process. Roland V. Hutchinson. *S. A. E. Jour.*, **42**, 89–100 (1938).—Heating of both work and wheel increases at a much faster rate than the dulling of the grain. Work heating may be reduced by a stronger abrasive, weaker bond, wider abrasive grain spacing, or increased wheel speed and is in part proportional to length of chip path, which is proportional to the square root of the radial depth of cut. Thickness of chip is roughly proportional to radial depth of cut. Wheel heating depends on the rate of dulling and the extent of the filling of intergrain spaces. Climb-cut grinding reduces heat somewhat and can reduce friction between the wheel and the work. With materials which heat check, a cool wheel but not a coolant should be used. A hard-grained weak-bonded open-textured wheel should be used at high speeds. In cylindrical grinding, openness of texture should increase with transverse speed. In finish grinding, minimum disturbance of the wheel surface by dressing is desired. Minimum conformity between wheel and work will decrease scratches from loose abrasive grains. Climb-cut grinding may give fewer scratches on finishing. In an ideal application, after a wheel is dressed, its self-sharpening due to breakdown compensates its dulling tendency from the work done. A type of grinding wheel dynamometer is suggested for measuring the factors involved which might predict the right wheel to use. W.D.F.

Polishing and buffing of zinc base die castings and aluminum die castings. T. C. Eichstaedt. *Monthly Rev. Amer. Electroplaters' Soc.*, **25**, 607–11 (Aug., 1938); *Metals & Alloys*, **9** [12] MA 718 (1938).—Die castings have a burr when they are taken from the caster which is removed by polishing with 120-grain emery followed by 180-grain emery. An abundance of grease stick should be used, and the pressure against the wheel should not be too high or the metal will drag. The die castings are buffed and colored in the usual fashion. The Butler satin finish is obtained by subjecting the buffed castings to a smaller wheel (10 in. diameter), the speed of which is less than 1800 r.p.m., and by using a greaseless compound. The Butler finish on Al die castings is produced with a steel scratch brush less than 8 in. in diameter and having a speed below 1500 r.p.m. No grease or buffing compound is used.

Stressing, wear, and grinding of rolls for the production of heavy and light plates and sheets. O. Emicke. *Stahl*

& Eisen, **58**, 73–82, 112–17, 136–45 (1938).—E. considers, both theoretically and practically, the following topics in connection with rolls: (1) the material used in the manufacture of rolls and the stresses to be resisted; (2) the wear of rolls; and (3) the grinding of rolls. The requirements and construction of grinding wheels, balancing and truing of the wheels with diamonds, checking of the accuracy of grinding with gauges, and the fitting up of grinding machines are also dealt with. L.R.B.

Surface allotropic transformation in stainless steel induced by polishing. J. T. BURWELL AND J. WULFF. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1032; *Metals Tech.*, **6** [2] 6 pp. (1939).—Electron diffraction studies of polished surfaces of an 18/8 stainless steel containing 0.08% C showed that polishing transforms the otherwise austenitic (gamma iron) metal to a 90% ferritic (alpha iron) condition to a depth of about 2.5×10^{-4} cm. below the polished surface. The working of the metal may extend to depths lower than this, but not enough to effect the transformation. F.P.P.

PATENTS

Abrasive article and method of manufacturing. F. J. TONE (Carborundum Co.). U. S. 2,152,392, March 28, 1939 (Jan. 26, 1937).—A relatively stiff but flexible abrasive disk.

Abrasive-coated material. RAYMOND C. BENNER AND ROMIE L. MELTON (Carborundum Co.). Can. 379,900, March 7, 1939 (Aug. 15, 1938). G.M.H.

Abrasive wheel and method of manufacture. BAALIS SANFORD AND D. E. WEBSTER (Norton Co.). U. S. 21,043, April 4, 1939 (June 8, 1938); reissue of original U. S. 2,085,705 (*Ceram. Abs.*, **16** [9] 264 (1937)).—A method of making rubber-bonded abrasive bodies comprises forming rubber into a sheet, dieing out the sheet into desired shapes, introducing the shapes into a mold with a vulcanizing agent, spreading abrasive grain on the rubber after it is in sheet form, the abrasive grain being distributed throughout the mold and in contact with each shape, pressing, and vulcanizing.

Apparatus for bench grinding long blades. W. F. OCENASEK (Walker-Turner Co., Inc.). U. S. 2,153,502, April 4, 1939 (Oct. 12, 1936).

Apparatus for manufacture of abrasive coatings. C. W. BRYAN (Ansonia Coated Abrasives, Inc.). U. S. 2,151,737, March 28, 1939 (Aug. 29, 1935).

Automatic knife-blade grinding machine. CLARENCE LUDWIG. U. S. 2,151,480, March 21, 1939 (May 14, 1937).

Blade sharpening machine. W. W. HARTMAN. U. S. 2,151,204, March 21, 1939 (Aug. 9, 1937).

Bonded abrasive and method of making. N. P. ROBIE (Carborundum Co.). U. S. 2,154,185, April 11, 1939 (Sept. 30, 1937).—The improvement in the process of making articles from granular material bonded with a difficultly fusible but solvent-softenable binder comprises preparing a mixture of granular material and binder of the character specified, forming a shaped mass from the mixture, and subjecting the shaped mass to the vapors of a solvent for the binder under superatmospheric pressure to bring about bonding of the granular material.

Circular grinding machines. F. NEUGART. Brit. 501,483, March 15, 1939 (April 12, 1937).

Crankshaft grinding machine. H. A. SILVEN (Norton Co.). U. S. 2,151,666, March 21, 1939 (Oct. 18, 1935).

Crank throw grinding device. J. P. MORRIS. U. S. 2,151,139, March 21, 1939 (Dec. 24, 1937).

Device for grinding bearing surfaces having two inclinations. OTTO WAGNER AND WALTER PILZ. Ger. 669,776, Dec. 8, 1938 (July 20, 1937); XII/67*a*. 10.—A device for grinding bearing surfaces having two inclinations, particularly railroad wheels, by means of a grinding surface with two inclinations corresponding to the bearing surface is described. It consists of two ring-shaped grinding wheels, each operating with its face and each intended for working an inclination; the wheels are placed concentrically within each other and are adjustable while grinding in the axial direction. D.A.B.

Gear grinding machines. J. E. REINECKER AKT.-GES. Brit. 501,553, March 15, 1939 (Oct. 12, 1936).

Grinding disk. JAN FOU (Ernst Winter & Sohn). Ger. 669,700, Dec. 8, 1938 (June 9, 1937); XII/67*c*. 1.—A grinding disk working with its surface perpendicular to the axis of the tool has its grinding ring of abrasive particles and artificial resin compound fixed in a U-shaped depression of the supporting disk. The inner wall or partition of the depression is provided with openings, and the length and thickness of the remaining parts are determined to produce flexibility which corresponds to the pressure resulting in the shrinking of the grinding wheel. D.A.B.

Grinding, gauging, and sizing. R. H. CRAMER (General Motors Corp.). U. S. 2,152,875, April 4, 1939 (Nov. 23, 1937).

Grinding machine. H. N. NORMAN. U. S. 2,153,476, April 4, 1939 (March 17, 1938). W. H. WOOD AND C. G. FLYGARE (Norton Co.). U. S. 2,151,669, March 21, 1939 (Feb. 29, 1936).

Grinding machine steady rest. C. G. FLYGARE AND I. A. TAYLOR (Norton Co.). U. S. 2,151,636, March 21, 1939 (July 20, 1938).

Grinding wheel spindle reciprocating apparatus. C. G. FLYGARE (Norton Co.). U. S. 2,151,655, March 21, 1939 (June 1, 1936).

Grinding wheel trimming device. ADAM ROMAN (Westinghouse Electric & Mfg. Co.). U. S. 2,151,802, March 28, 1939 (Oct. 27, 1937).

Hydraulic surface grinding machine. C. G. FLYGARE AND H. A. SILVEN (Norton Co.). U. S. 2,151,637, March 21, 1939 (Aug. 18, 1938).

Lapping device, apparatus, and method. H. S. INDGE AND A. G. BELDEN (Norton Co.). U. S. 2,153,521, April 4, 1939 (Feb. 5, 1938).

Lapping machine. G. E. HULBERT AND H. S. INDGE (Norton Co.). U. S. 2,151,473, March 21, 1939 (May 23, 1936; May 18, 1938).

Machine for centerless grinding articles such as tapered rollers. G. D. WINKLER (Tyson Roller Bearing Corp.). U. S. 2,151,365, March 21, 1939 (Aug. 26, 1937).

Machine for grinding the relieved threads of screw-cutting hobs and taps. F. TURRETTINI. Brit. 502,123, March 22, 1939 (Oct. 29, 1937).

Machine for grinding or sharpening edge tools. E. G. SCHULZE. U. S. 2,153,275, April 4, 1939 (Dec. 14, 1936).

Polishing machine. W. H. WOOD (Norton Co.). U. S. 2,151,670, March 21, 1939 (Oct. 21, 1938).

Polishing machine fixture. J. H. GOULD (Houdaille-Hershey Corp.). U. S. 2,151,909, March 28, 1939 (March 25, 1938).

Pulpstone. HUGO W. H. BETH (Norton Co.). Can. 379,676, Feb. 21, 1939 (Aug. 11, 1937). G.M.H.

Truing tool for grinding wheels. WALTER STADELBAUER. U. S. 2,151,572, March 21, 1939 (June 11, 1938).

Universal sharpening tool and work holder. C. C. CHARTIER. U. S. 2,152,729, April 4, 1939 (Aug. 26, 1935).

Valve stem grinder. H. C. PRESTON (Black & Decker Mfg. Co.). U. S. 2,151,528, March 21, 1939 (Feb. 14, 1936).

Ventilated buffing wheel. HARRY ZIMMERMAN (Canadian Hanson and Van Winkle Co., Ltd.). Can. 379,602, Feb. 14, 1939 (Jan. 29, 1938). G.M.H.

Wheels for grinding. DEUTSCHE NORTON-G.M.B.H. Ger. 666,845, Oct. 29, 1938; 67*c*. 1; *Chem. Abs.*, **33**, 2305 (1939).—The performance and life of grinders are improved by soaking them with a hygroscopic salt solution, *e.g.*, of $ZnCl_2$.

Work holder for grinding machines. W. M. MCAFEE (Federal-Mogul Corp.). U. S. 2,153,261, April 4, 1939 (June 14, 1938).

Art and Archeology

Abaquesne and his work. M. DEHLINGER. *Céram., Verrerie, Email.*, **6** [11] 345–48; [12] 379–86 (1938).—Masseot Abaquesne was the first to make true faience in France. His work was original and was known as "Faience of Abaquesne." From dates on pieces signed by him, his work can be traced from 1526 to the time of his death in 1564. He learned the rudiments of the potters' art in Normandy but to learn the making of faience, which at that time was known only by the Italians, he came to Paris to the Italian workshop established by Jerome della Robbia at Suresnes. For a long time he was unknown, and his work was ascribed to Bernard Palissy. He was discovered by Andre Pottier of Rouen, who, during the restoration of the Chateau of Ecouen, discovered tile bearing the inscription "At Rouen 1542," which was before the maturity of Palissy. This discovery was corroborated by findings in archives. A study of the technique of the faience of Abaquesne showed that the clay used was a brick red or delicate rose and sometimes grayish white and was usually hard, fine, arenaceous, and compact. The enamel is usually thick and grayish white and is sometimes fat; when applied thinly, it has a rose tint because it is transparent and shows the clay beneath. The glaze on the enamel does not have the brilliance of Italian faience. The enamels are cobalt blue (often dark), light lemon yellow, orange (which replaces the Italian ocher which Abaquesne could not achieve), and light and dark copper green; less frequent colors are violet of manganese, maroon, and bister. Only a few pharmacy jars and numerous tile pavements remain of his work. These are described. See "Palissy—," *Ceram. Abs.*, **16** [9] 266 (1937). M.V.C.

Animal imagery illustrated by examples in the Eumorfopoulos collection. WOLFGANG BORN. *Connoisseur*, **103** [449] 23–28 (1939).—Animal symbolism has come down through the various civilizations in repeated types until it has lost its original significance. The ceramic pieces in this collection consist of the Chinese whistle shaped as an ox head, ascribed to the Wei dynasty (5th or 6th century A.D.) by reason of the dark clay, then in use, of which it is made; vessels in the form of fish, which are of ancient Syrian glass from the 4th and 5th centuries; and a glass snake, dating from the 4th century, also Syrian. Illustrated. M.E.P.

Biskupin. J. KOSTRZEWSKI. *Sci. Amer.*, **160**, 154–56 (1939).—Near this village in north Poland a prehistoric fortified village existed on the shore of a lake from about 700 to 400 B.C. Inundation by the lake caused its abandonment. It consisted of about 100 wooden huts. A large amount of pottery was preserved, some quite coarse and some of finer types, such as incised vessels incrusted with white material or painted with red ocher. Conventional figure drawings were used for decoration. There are also some blue glass beads (probably from Egypt), clay molds for casting necklaces, pins, etc., and many objects of bronze, wood, and stone. W.D.F.

Citadel of Van. KIRSOPP AND SILVA LAKE. *Asia*, **39**, 75–80 (1939).—The citadel is in eastern Anatolia on top of a hill. A pit sunk south of the hill did not show the city but disclosed a thin layer of fine red pottery sherds. East of the citadel on the north slope of the hill an altar platform was found. Excavation showed large buildings and fortifications just above this. A large amount of heavily decorated buff pottery was found here. An inscription on the red pottery resembled an Assyrian seal; it was dated not later than 600 B.C. Work was transferred to Kalehjik, a smaller Vannic citadel 5 miles north. Here red pottery was found overlying the buff. A great many obsidian implements were also located. The Vannic sherds were found on the hills and not near the small villages on the plains, which suggests that the conquerors lived on the hills and disappeared without influencing the peasant culture. W.D.F.

Cut glass after 2000 years of experiment. W. W. WINKWORTH. *Arts & Dec.*, **49** [6] 25–27 (1939).—Since Roman glass was almost always strongly tinted green or brown, the walls of vessels had to be made thin to allow passage of light. This limited the deeper cutting of the glass and resulted in cameo effects with little or no brilliance. The engraved grooves ran longitudinally instead of horizontally. Modern glass is almost flawless and can be cut with emphasis on design or brilliance or both. The vogue for cut glass is returning. Illustrated. L.F.M.

English enameled drinking glass. *Connoisseur*, **103** [449] 45 (1939).—The goblet recently discovered by W. G. T. Burne is a rare example of an 18th-century English drinking glass. The bowl is finely enameled with a pastoral landscape in colors with cartouche breaking into scroll foliage and Vandyked borders in opaque white enamel, the work of Beilby of Newcastle-on-Tyne about 1760. Only two of the perfect glasses of this type are known. Illustrated. M.E.P.

Gardner porcelain for four Russian orders of knighthood. HELEN COMSTOCK. *Connoisseur*, **103** [449] 38–39 (1939).—At the gallery of Old Russia in Boston are examples of original services made for Catherine II bearing the emblems of the orders of St. George, St. Andrew, St. Alexander Nevsky, and St. Vladimir. The first three of these were started in Francis Gardner's factory in Moscow in 1777, and the last, in 1782. The St. Vladimir set for 160 guests was the largest service. Replacement pieces were made later at the Imperial factory. Illustrated. See *Ceram. Abs.*, **15** [1] 3 (1936). M.E.P.

History and romance of Lancashire and Cheshire ceramic art. F. FIDLER. *Trans. Lancs. & Cheshire Antiquarian Soc.*, **52**, 67 (1937); *Trans. Brit. Ceram. Soc.*, **38** [2] 20A (1939).—John Dwight took out the first of his two patents for china manufacture when he was at Wigan in 1671. About six years prior to this, at York, Francis Place made a whiteware which was then described as equal to true china. Place devoted the latter part of his life to artistic and experimental pursuits, but his work as a potter was exploited by Clifton who made a fortune by it. Place made a whitish ware which, however, did not reach the standard of Dwight's white stoneware; no known examples of their ware demonstrate that either ever made a true china body. The year after Josiah Wedgwood set up in business, Richard Chaffers made a fine white earthenware at Liverpool, and in the same year Sadler, of Liverpool, invented the art of transfer printing on china. In 1761 Wedgwood was beginning to make his journeys to Liverpool, where he was introduced to Thomas Bentley, who exercised a refining influence on the quality of Wedgwood's productions. Wedgwood obtained the first supplies of barytes for the production of his jasper ware from lead mines in Lancashire, while improvements in appliances and special tools for the making of pottery were largely due to certain smiths in Congleton, Cheshire.

Islamic monuments of Iran. MYRON BEMENT SMITH AND KATHERINE DENNIS SMITH. *Asia*, **39**, 213–19 (1939).—Over a period of five years an exhaustive study was made, in coöperation with the Iranian Archeological Service, of important early Islamic monuments; sites for excavation were located. The great mosque at Isfahan (Masjidi-i Jum'a) was particularly studied; this existed before A.D. 995, and additions, embellishments, and repairs were made during the Seljuk, Mongol, Muzaffarid, Timurid, Safavid, Kajar, and Pahlevi dynasties, *e.g.*, fourteen different layers of thin plaster covered one example of fine Seljuk brickwork. The authors compared this with other buildings all over Iran, finding dates for them and studying their architecture carefully. This building is constructed mainly of brick, including piers, arches, vaults, and stalactites. Decorations are in carved and painted stucco; faience was also used. W.D.F.

Jockey Hill, painter of ceramics: I. WILLIAM H. TAPP. *Connoisseur*, **97** [418] 316–17 (1936).—T. points out from studies of the Derby pattern books and the George Mellor papers that "Jockey" was Thomas Hill who first made his appearance at the factory about 1794. He began working at the Chelsea china factory but later appeared at the Derby factory where his first pattern is dated 1795. Because he rode to work daily on his pony he was nick-

named "Jockey." His work resembles that of Boreman to whom he was apprenticed earlier, but he had outstanding characteristics of his own such as the splashes of russet and brown tones and the sharp minute brush strokes in place of stippled effects on leaves and foliage. II. *Ibid.*, **98** [420] 142–44 (1936).—The rather indefinite finish in his work is due to the fact that he was a rapid worker and had only two full fingers on his right hand, due to an accident in his early life. His works are, however, always true representations of rural subjects. His sharp contrasts in color distinguish his work from Boreman's, whose Derby work is often confused with Hill's. Illustrated. M.E.P.

Late Ming harlequin figure and two early K'ang Hsi vases of the *Famille Noire* and the *Famille Verte* groups. *Connoisseur*, **103** [449] 43 (1939).—Full-page color illustration. See *Ceram. Abs.*, **18** [1] 5; [3] 67 (1939). M.E.P.

Modern ceramics in gay design. ANON. *Arts & Dec.*, **49** [4] 12–13 (1939).—Ceramic figures, fantastic articles of sculpture, and pottery which have been exhibited nationally are illustrated. L.F.M.

Neglected treasure trove at the gates of India. BENJAMIN ROWLAND, JR. *Asia*, **39**, 46–50 (1939).—In northwestern India, particularly near Charsadda, are many mounds of ruins. Specimens from two large mounds at Sari Dheri range from material resembling that of the Indus Valley (3300 to 2000 B.C.) to that of A.D. 300 or 400. These mounds are being used by the natives for fertilizer. The primitive terra-cotta statuettes resemble those found at other sites, such as Chanhu-daro, Mohenjo-daro, Kish, Taxila, etc., indicating the extension of Indus Valley culture to northwest India and a link with Mesopotamia. W.D.F.

Sialk: prehistoric Iran. R. GHIRSCHMAN. *Asia*, **38**, 645–50 (1938).—Sialk is near Kashan, 250 km. south of Teheran. Civilization began here in the fifth millenium B.C. The second layer had pounded-earth houses and large pottery jars with a wickerwork design, although the potter's wheel and kiln were unknown; well-carved bones were used as flint-sickle handles. The first period had five levels. The second period, with three levels, showed the use of the potter's kiln, and a red ware with geometric design was made. The third period had eight levels, with houses of molded brick. Large potsherds were inserted into the wall between brick and plaster as insulation against dampness. The potter's wheel had been invented; decorations were figures of animals and men. This civilization was violently overthrown by a new one characterized by monochrome red or black vases. About 3000 B.C., clay tablets with numbers appeared, the first attempt at writing. Sialk was then uninhabited for nearly 2000 years. The new civilization built important buildings and had a separate graveyard at a short distance. Many pottery objects were found in the graves, including a pitcher, decorated geometrically, with a long spout and a handle. These people belonged to the same group of Indo-Iranians as the Medes and the Persians. W.D.F.

Solomon's seaport, Ezion-Geber. NELSON GLUECK. *Asia*, **38**, 591–95 (1938).—At the head of the gulf of Aqaba, about 500 yards from the present shoreline, the remains of a large copper refinery made of mud brick were found. The city was located to take best advantage of strong local winds for draft for the furnaces. It was an important market place, industrial center, and seaport. The pottery found dates from the 12th to the 8th century B.C. A small jug was inscribed with the first Edomite inscription ever found. W.D.F.

Vase of three-color porcelain with the Eight Immortals of the Wine Cup in a landscape. *Connoisseur*, **103** [451] 153 (1939).—This full-page color illustration shows a 16-in. Chinese (Ming) vase of the 15th century. M.E.P.

When Greek and Oriental cultures met at Seleucia. NEILSON C. DEBEVOISE. *Asia*, **38**, 746–51 (1938).—Seleucia was located on the Tigris about 30 miles from Baghdad. It was founded by Seleucius, one of Alexander the Great's generals, and was occupied by Parthians in 141 B.C. The city declined and was later occupied in Sassanian times (A.D. 226 to 637). The city was laid out in rectangular blocks; the block excavated showed Sassanian remains on top, three levels of the Parthians, and the Hellenistic city, which was studied only slightly. Two large Parthian "temples" were found elsewhere in the city. In the private houses, figurines, coins, and pottery were most abundant. Local pottery was in many shapes; a blue-green glaze was used, and brown and cherry-red glazes of the Seleucid period carried over into the Parthian. Jars ranged in height from 1 in. to 4 ft. Few written records remain, as they were mainly on parchment. This excavation provides a link between the Seleucid and Parthian periods and between the Parthian and Sassanian periods. See *Bull. Amer. Ceram. Soc.*, **13** [11] 293–300 (1934). W.D.F.

Wine jar (Ming dynasty). *Connoisseur*, **97** [418] 347 (1936).—Full-page illustration in color of a jar dated about 1500. The 11.6-in. ovoid-shaped body with a short straight neck is glazed green inside. The lip projects slightly. The details are incised. It is from the Eumorfopoulos collection. M.E.P.

PATENTS

Designs for:

Bottle. LENTHÉRIC OF CANADA, LTD. Can. 12,244, Feb. 2, 1939. G.M.H.

Bottle. R. A. BLUNT. U. S. 114,004 to 114,009, March 28, 1939 (Nov. 7, 1938). J. L. DUNNOCK (Swindell Bros., Inc.). U. S. 114,208, April 11, 1939 (Feb. 2, 1939). W. R. KOHL (Carr-Lowrey Glass Co.). U. S. 113,867, March 21, 1939 (Jan. 6, 1939). W. R. LEACH (Carr-Lowrey Glass Co.). U. S. 113,869, March 21, 1939 (Jan. 3, 1939).

Building block. A. H. STAMM AND H. S. BARTON. U. S. 113,978, March 28, 1939 (Sept. 3, 1938).

Combined glass powder and powder puff container. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,180, April 11, 1939 (Feb. 8, 1939).

Cosmetic jar. JOHN H. WOODBURY, LTD. Can. 12,252, Feb. 14, 1939. G.M.H.

Folding type closet bowl and mounting therefor. LEIF ANDERSEN, E. A. FREDRICKSON, T. P. NEWMAN, H. R. VAN SCIVER, AND R. H. ZINKIL. U. S. 114,166, April 11, 1939 (June 18, 1938).

Glass bottle. JOHN H. WOODBURY, LTD. Can. 12,239, Jan. 25, 1939. G.M.H.

Glass candleblock. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,217, April 11, 1939 (March 6, 1939).

Glass floral bowl. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,182, April 11, 1939 (Feb. 11, 1939).

Glass jelly dish. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,181, April 11, 1939 (Feb. 8, 1939).

Glass torte plate. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,183, April 11, 1939 (Feb. 16, 1939).

Glass tumbler. R. J. BEATTY. U. S. 114,054, April 4, 1939 (Jan. 12, 1939).

Hollow glass building block. E. P. LOCKART (Owens-Illinois Glass Co.). U. S. 114,085 and 114,086, April 4, 1939 (Feb. 6, 1939).

Jar. GEORGE SMITH, JR. (Olean Glass Co.). U. S. 114,240, April 11, 1939 (Feb. 17, 1939).

Plate. LOUIS CRUVEILHER (Gunthel & Cruveilher). U. S. 114,173, April 11, 1939 (Dec. 16, 1938). W. J. FREY. U. S. 114,175, April 11, 1939 (Jan. 28, 1939). C. W. LEIGH (Morimura Bros., Inc.). U. S. 114,072 to 114,079, April 4, 1939 (Jan. 5, 1939). U. S. 114,080 to 114,083 and 114,107, April 4, 1939 (Jan. 12, 1939). U. S. 114,309, April 11, 1939 (Jan. 5, 1939).

Swivel type closet bowl and mounting therefor. LEIF ANDERSEN, E. A. FREDRICKSON, H. R. VAN SCIVER, AND R. H. ZINKIL. U. S. 114,167, April 11, 1939 (June 18, 1938).

Cements

Hydration of calcium aluminates, their double salts, and calcium silicate. JACQUES LEPOL. *Congr. Chim. Ind., 17me Congr., Paris,* **1937, II,** 562–71C; abstracted in *Chem. Zentr.,* **1938, II,** 3665. M.V.C.

Macrostructure of Portland cement clinker. B. TAVASCI. *Tonind.-Ztg.,* **62** [72–73] 794–95 (1938).—A polished cross section of cement clinkers etched with a 1% solution of borax gives a good picture of the structure when enlarged 6 to 10 times and allows an approximate estimation of the constituents for study and for process control. Photos enlarged 10 and 100 times are discussed in detail. W.K.

Magnesia of Portland cement: VIII, Raw mixtures of high magnesia content. Y. SANADA AND G. NISHI. *Jour. Soc. Chem. Ind. Japan,* **41** [2] 36B (1938).—Mixtures of high magnesia content were heated in an electric resistance furnace to 800°, 1000°. 1200°, and 1400°C for 2 hr. The composition of the clinker obtained and the free lime and free magnesia determined are given in tables. **IX, Rate of hydration of magnesia.** *Ibid.,* [4] 90B (1938).—The rate of hydration of magnesia calcined at 800°, 1000°, 1200°, and 1400°C for 2 hr. was studied. The rate was retarded as the temperature increased. The hydration of magnesia calcined at 800°C proceeded rapidly for 7 days; after that it was very slow. The hydration of magnesia calcined at 1000°, 1200°, and 1400°C proceeded rapidly for 28 days and then slowed down. For Parts III–VII see *Ceram. Abs.,* **17** [5] 173 (1938). M.V.C.

New conceptions of compounds formed in the hydration of Portland cement. SIGERU YAMANE. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **34** [786] 515–25 (1938) (in Esperanto).—The prevailing conception of the existence of calcium sulfoaluminate, calcium aluminates, and calcium silicates in the liquid phase during the hydration of cement is probably correct in special cases only. Ordinarily a sulfoaluminosilicate ($5CaO \cdot Al_2O_3 \cdot SiO_2 \cdot \cdot 4CaSO_4 \cdot 44H_2O$) is formed. In powdered clinker free from $CaSO_4$, mixtures of calcium aluminosilicates are formed. These mixtures form two isomorphous series with interchange of aluminum and silicon. One series is based on $4CaO \cdot Al_2O_3 \cdot 15H_2O$, and the other, on $2CaO \cdot SiO_2 \cdot 5H_2O$. An approximate formula for the mixture is $2CaO \cdot \cdot (Al, Si)O_m \cdot nH_2O$. J.B.A.

PATENTS

Cement and process for manufacture. A. T. B. KELL. Brit. 502,044, March 22, 1939 (Sept. 15, 1937).

Production of sintered products. HELMUT WENDEBORN (American Lurgi Corp.). U. S. 2,152,718, April 4, 1939 (May 13, 1937; Dec. 27, 1937).

Enamel

Adhering power of enamels on cast iron. VIELHABER. *Emailwaren-Ind.,* **15** [49] 319–20 (1938).—Enamels adhere less closely to cast iron than to sheet metal because they do not sink in deeply in as many places on the cast iron as on the sheet metal. Tests on the adherence of enamel by dropping a weight or hammer directly on the surface of the enamel or on the back of the enameled object are conditioned by (1) thickness of the iron; (2) dimensions of the test piece (enamel breaks off more easily from large surfaces than from small surfaces); (3) expansion due to heat of the enamel coat; (4) condition of the surfaces of the cast iron; (5) structure of the iron crystals; and (6) permanent change in expansion of iron during enameling (studied by Outerbridge in 1909 and Carpenter in 1911). M.V.C.

Automatic blasting. E. B. RICH. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 145–50.—R. points out the inefficiency of pneumatic propulsion of abradant material and outlines the history, development, and advantages of centrifugal blasting or the airless mechanical propulsion of abrasive. F.J.Z.

Automatic spraying and brushing equipment. J. F. ROCHE, JR. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 200–208.—Automatic equipment is installed to produce a quality finish and to lower the cost of finishing by increasing production and reducing the percentage of rejects or reclaims. F.J.Z.

Ball-milling practice. A. H. BURNHAM, JR., AND H. SECHRIST. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 79–82.—Work is in progress to determine (1) effect of size of balls on grinding, (2) effect of combination of sizes, (3) effect of mill speed on size of grinding balls or combinations, and (4) effects of variables on efficiency of ball-mill operation. **Discussion.** D. H. ROWLAND, ET AL. *Ibid.,* pp. 82–89. F.J.Z.

Black specking of hollow ware. E. C. DEXHEIMER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 106–17.—D. believes that there is no single practice in the shop which may not have some influence on the tendency of black specks to appear and disappear. Variations in steel, methods of pickling, temperatures, and acids did not disclose definite causes of black specking. Annealing the shapes seemed to increase the black-specking tendency. A borax neutralizing bath reduced spots below those obtained when soda neutralizer was used. Water containing an abnormal amount of chloride salts caused increased black specking. Underfiring the ground coat and using a high water content in the furnace atmosphere increased specking. D.'s account of numerous experiments on black-specking tendencies is followed by a discussion. F.J.Z.

British enameling practice. A. ENGLAND. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 61–72.—Application of glass coats to cast iron hollow ware in England dates back to the beginning of the 19th century, and it is thought that white enameled sanitary ware was introduced about 1887. E. names four essentials to be considered in the formation of enamels, *viz.,* melting temperature, expansion, elasticity, and durability. The work on expansion and elasticity is briefly reviewed. The dry-process and wet-process methods used on cast iron and the wet-process method used on sheet iron are briefly described. Leadless enamels are preferred, and tin oxide and metantimonate of soda or potash are used as opacifiers. F.J.Z.

"Burning off" sheet- and cast-iron ware for enameling. H. LANG. *Glashütte,* **68** [20] 343–46 (1938).—L. discusses in detail the importance of burning off sheet- and cast-iron ware before enameling, with special regard to duration and temperature. Sheet-iron ware is usually burned off at 600° to 650° and cast-iron ware, at 750° to 800°. There should be a difference of at least 50° between the temperature of firing the enameled ware and that of burning off. M.V.C.

Burning tools for enameling. D. W. TALBOTT. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 193–99.—Two classes of tools are discussed, *viz.,* bucks and supports for cast iron and supports and hangers for enameling sheet metal. Tools of alloy castings should have (1) great oxidation resistance, (2) no loose scale formation which may drop on the ware, causing specks, (3) ability to stand thermal shock, (4) light weight to lessen heat loss, (5) sufficient load-carrying strength at elevated temperatures, (6) stiffness and freedom from directional properties such as are apparent in rolled material, (7) smooth cast surfaces for economical handling and carefully ground corners to eliminate all sharpness, and (8) sections producing uniformity in heating and cooling to eliminate uneven heating of the ware. F.J.Z.

Centrifugal method of blasting. ANON. *Emaillerie,* **6** [8] 7–8 (1938).—This method of cleaning consists of throwing the abrasive by centrifugal force against the

parts. The device is described. It is similar to a barrel sandblast, but as no air is used and the operation is carried on inside the machine practically no dust is made. It is specially useful for small castings, stove parts, etc. For larger work, a table machine has been developed; no air is used, and the power cost is lower. When loading the pieces, it is recommended that the pieces be kept in motion to avoid a cutting action. M.D.

Chipping resistance of enamels. PAUL L. SMITH. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 37–47.—S. attempts to produce the kinds of failures of importance commercially on simple shapes where they can be studied. Brittle materials such as glass and enamel fail only in tension; they do not fail by sliding, as metals do, or by being pushed together. As a crack travels in a brittle material, it tries to keep perpendicular to the direction of maximum tension. In impact failures, the effect of local forces around the area of impact and the effect of the bending of the whole piece must be considered. S. describes the pendulum-type apparatus used to test various kinds of commercial ware as well as laboratory specimens. F.J.Z.

Circulating ground-coat systems. RAY HARNER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 187–93; see "Ground—," *Ceram. Abs.*, **17** [9] 300 (1938). F.J.Z.

Color matching of white parts. G. H. MCINTYRE. *Proc. Porcelain Enamel Inst. Forum, Third Forum., Oct., 1938,* pp. 163–87.—Any two samples which appear to be an exact color match to all observers under all conditions must have exactly the same spectral reflection characteristics as well as identical surface structure and gloss. In making color analyses with the spectrophotometer, the reflectances of all wave lengths are measured separately by resolving white light into its components with a prism. For all practical purposes, satisfactory color analyses may be obtained by measuring reflectance values with a suitable instrument such as the Hunter reflectometer in three ranges of the spectrum (blue, green, and amber), the light of selected wave length being obtained by appropriate filters. If the enameled samples were a neutral white, the reflectance at any given thickness or weight of coating would be identical for the whole spectral range, and therefore the blue, green, and amber curves would be superimposed. The degree of spread of the blue curve over the green as compared with that of the amber curve over the green indicates the extent to which the enamel appears as a blue-white color. M. describes methods for color matching used in production plants. Vitamin A has been found helpful in overcoming fatiguing effect in inspectors' eyes. The problem of color matching white parts is more serious in the case of resprayed or reworked parts, as reflectance increases rapidly with increasing application. A material which actually stabilizes the reflectance and color to any desired predetermined value, regardless of weight of application of the recoat enamel, has been developed. The color matching of white parts may be reduced to an exact process by the application of the laws of light reflectance, the prevention of eye fatigue of inspectors, and the use of modern materials available for the control of color selectivity and ultimate reflectance. F.J.Z.

Comparisons of English and American enameling plants C. P. STONE. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 222–26.—In England, white and ground coats are applied as they are in America. Color is applied very thinly with a 12-in. brush and smoothed out with a badger brush, which extracts most of the water. Such enamel is ground without clay and is suspended in water without the aid of a setting-up agent. Cast-iron stoves or cookers with acid-resisting finish are popular in England. Lead enamels are not used. F.J.Z.

Control of gray enamel manufacture. H. D. CARTER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 117–33.—Mottling is produced by the rusting of the metal base as influenced by the applied enamel upon drying. Factors which influence mottling are (1) alkalinity of the milled enamel, (2) surface of the metal, and (3) drying. C. discusses the methods used for controlling each in a production plant. F.J.Z.

Deënameling. VIELHABER. *Emailwaren-Ind.*, **15** [49] 321 (1938).—It is unprofitable for every enameling plant to install deënameling equipment, but it would be advantageous for several enameling works situated near each other to have a deënameling plant located in their vicinity. M.V.C.

Dry-process enameling. E. E. HOWE. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 150–62.—H. describes the type of black specks produced in dry-process ware by contamination with molding sand, aluminum paint, silicon carbide, titanium, iron, zinc, coke and carbon, antimony, and colored frits. Photomicrographs and a discussion are included. F.J.Z.

Effect of treating cast iron with caustic soda. T. L. JOSEPH, F. W. SCOTT, AND M. TENENBAUM. *Metals & Alloys*, **9** [12] 329–35 (1938).—The transverse strength of cast iron was increased by the addition of caustic soda. Although the graphite flakes showed a tendency to be thinner and less blocky after the treatment, the increase in strength is largely attributed to the removal of S. No relation was found between transverse breaking load and the oxide content of the metal adjacent to the fracture. Alkalis are oxidizing and will accordingly form silicates, which may or may not be eliminated. The addition of alkalis below the surface results in a vigorous reaction and rapid elimination of S. F.P.P.

Enamel and its application. ANON. *Emaillerie*, **6** [7] 10 (1938).—Examples of enamel as a successful finish are illustrated. M.D.

Enamels without borax but with glass powder in 1895. ANON. *Emailwaren-Ind.*, **15** [51–52] 338 (1938).—Powdered glass was used in appreciable amounts in white enamels without borax in 1895. Unfortunately, batches with and without lead were permitted. A batch given by Bull contained 24.40 feldspar, 18.72 soda, 36.00 glass powder (milk glass), 6.28 sand, 6.32 fluorspar, 6.28 calcite, and 2.00 tin oxide. M.V.C.

Factors affecting sag-resistance properties of enameling iron. FRANK R. PORTER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 47–54.—The main factors affecting sag resistance are (1) chemical analysis of the iron, (2) temperature to which the sheet is heated, (3) gauge of sheet used, (4) distance between supports during heating, (5) time of heating, and (6) physical characteristics of the sheet. P. compares enameling iron with mild steel and graphically describes his results. F.J.Z.

Firing enamel in a furnace with a double grate. K. MACHWIRTH. *Glashütte*, **68** [46] 797–98 (1938).—Data on the life and yield of a furnace with a double grate, *i.e.*, alternating for successive firings, are given. A double grate had an economy of 33% over a simple grate in the case described. The hourly output in weight increased from 100 to 156 kg., and the output in pieces treated, from 220 to 338. A furnace with double grate consumes only 10% more coal. It is best adapted for firings of 4 to 5 min.; for heavy pieces the advantage is lost. The use of a double furnace permits the weight of the charge to be increased for each firing. The inconvenience of the introduction of the double grate in existing enamel works is that it requires a free space 3 m. wide on each side of the furnace. M.V.C.

Flash and roll seam welded assembly for enameling. C. G. BASSLER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938,* pp. 208–13.—Resistance welding may be divided into three general classifications: spot welding, roll seam welding, and flash butt welding. The Hart process for welding tubular sections is described. B. defines roll seam welding as the making of a series of overlapping spot welds by means of roll electrodes in continuous contact with the work for the entire length of the seam being made. F.J.Z.

Fluoride as flux. VIELHABER. *Emailwaren-Ind.*, **15** [48] 311–13 (1938).—Because of the scarcity of borax in Germany, other flux substitutes are being tested. Fluorides are known to have a greater fluxing action than the

alkalis. Fluorspar does not have the same fluxing action as cryolite. Andrews, whose study on the quantities of fluorides in the batch and their effect on the deformation temperature is quoted, explains that (1) the more cryolite is replaced by fluorspar, the higher the deformation temperature becomes; (2) even if results are dependent on the composition of the batch, the hypothesis is correct that it must be possible to obtain a reduction in the deformation point by the simultaneous use of more fluorides: cryolite, sodium fluosilicate, and fluorspar; and (3) the proportion in which these substances are present is important. Expansion, opacity, and batch composition are discussed. B. concludes that a formula with low borax content can be developed which uses fluorides and which will have satisfactory properties and be easily fusible. M.V.C.

Formation of oxides affects adherence of enamels. V. *Emailwaren-Ind.*, **15** [49] 320–21 (1938).—Adequate but not excessive oxidation of the iron surface under the enamel layer must occur in the first stage of firing to make the adherence uniform. Instructions for obtaining a uniform formation of oxides are given (F. Sutphen, *Enameling Observer*, Oct., 1938). M.V.C.

Glass in the enamel batch. VIELHABER. *Emailwaren-Ind.*, **15** [50] 329–30 (1938).—Glass powder can not be used in the enamel batch unless its composition is accurately analyzed and controlled. Glass is neither a substitute for borax nor a flux; it has the single advantage of shortening the fusing time somewhat because part of the silicic acid so introduced is in a more easily fusible form. M.V.C.

Historical development of enameling technique. RICHARD ALDINGER. *Glashütte*, **68** [22] 373–75; [23] 390–91 (1938).—Enamel was used in art or for jewelry by the Egyptians, Persians, and Chinese in ancient times. The origin and the development of technical enameling, *i.e.*, covering iron or other metal objects with a glasslike coat originally for the purpose of protecting it against heat or corroding liquids or for preventing food and drink from absorbing iron salts, were outgrowths of practical necessity; only later was enamel used for beautifying metallic surfaces. From the middle of the 18th century, when technical enameling was first practiced in the most rudimentary way, to the middle of the 19th century, enameling technique made little progress, although a greater need for enameled objects no doubt existed. This was due to (1) the strict secrecy in regard to enamel formulas and methods of the master enameler which confined the manufacture of enameled objects to a few localities and (2) the lack of development of iron founding and the production of sheet iron. Enamels with high lead content were used because they gave good results most easily under conditions where inadequate knowledge and the uncertain behavior of both iron and enamel made the outcome a matter of chance. Innovations were slow; the most important were the introduction of cryolite in 1890 and the gradual use of opacifiers.

Development of enamel industry

1761 J. H. Gottlob von Justi suggested glazing iron utensils.

1764 The Königsbronn plant in Württemberg made acid-proof enameled ware for chemical use and enameled stoves and cooking utensils.

1782 Sven Rinman, Swedish chemist and metallurgist, reported attempts to enamel sheet-iron objects.

1783 Heyer, from Braunschweig, tried to glaze iron vessels used for making medicine.

1785 The Gräfl. Einsiedel'schen plant at Lauchhammer in Kurfürstentum Saxony enameled cast-iron utensils, stoves, and pipes.

1793 In Birmingham, England, a factory for enameling copperware existed for a short time.

1799 Samuel Sandy Hickling obtained a British patent on a method of coating vessels of iron and other metals with a glasslike coat. Soon after, a factory was established.

1800–1825 Enamel works existed at the Royal Ironworks at Quedlinburg (sheet-iron ware), Royal Ironworks at Gleiwitz, Carlshütte (Lower Silesia), Elberfeld, Neuwied, Zellerfeld (Harz), Peitz (Kr. Cottbus).

1835 Enameled sheet-iron ware was made at the Thale Ironworks (Harz).

1836 Christoph Erbe from Schmalkalden published a book describing the manufacture and working of enamels free from lead.

1836 Anton Martin Pleischl, professor of chemistry and pharmacology in Prague, made known the discovery of a usable (lead-free) enamel for cooking utensils. An enamel plant was established in Vienna.

1839 In England, Thomas Clark and Charles Clark obtained a patent for enameling cast iron. For the first time ground frits and coat enamels (powder enamel) were differentiated. Both enamels were free from lead.

1850 The use of ground frit for cast iron and of clay as a mill addition was generally known.

1851 Textbook on the art of enameling, by Moritz Vogelgesang, was published by Vieweg, Braunschweig.

1856 Bessemer process.

1865 Siemens-Martin process.

Development of sheet metalware industry

1880–1900 Sheet-iron enameling plants existed throughout Germany in Saxon Erzgebirge, Rhineland, and Westfalen.

1890–1900 Greenland cryolite was used for enamels.

1894 Signboards were enameled in England.

1895 Textbook on the manufacture of enamel, by P. Bull, was published.

1900–1910 Tin oxide was used as mill addition. New opacifiers were gradually adopted.

1900–1914 First scientific research work was done on enamels. M.V.C.

Institute and the plant man. CHARLES S. PEARCE. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 27–31.—The Porcelain Enamel Institute was organized to promote porcelain enamel in all fields. F.J.Z.

Methods of testing enameling stock. H. W. ALEXANDER. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 55–60.—Desirable qualities of enameling iron are (1) wide ground-coat firing range, (2) good ground-coat adherence at normal firing temperature and time, (3) good sag resistance, (4) uniform ground-coat pickup on all sheets, (5) clean surface as received from the rolling mills, (6) freedom from sheet-metal surface defects, (7) physical properties to meet the fabricating requirements, (8) copperheading and delayed fishscale resistance, (9) satisfactory performance under all types of welding in use, and (10) good enameling results. Methods of testing for these qualities may be found in previous literature, but in some cases the tests given are adaptations of other tests used in enameling. F.J.Z.

Mill additions: Sundry mill additions. M. J. BAHNSEN. *Emaillerie*, **6** [7] 6–9 (1938).—Every kind of mill addition to be added to the frit to meet special requirements is reviewed, and the use of each material is explained. Borax, ammonium carbonate, and sodium nitrite act as rust inhibitors. Organic dyes are used for identifying certain types of porcelain enamels, those most commonly employed being methyl violet, phenolphthalein, Congo reds, etc. To give enamel a longer firing range, B. recommends adding feldspar or quartz in small amounts; zinc oxide enables the enamel slip to smooth out more easily on hollow ware. To obtain a good quality enamel, all materials must be clean and must contain no contaminating substances. See *Ceram. Abs.*, **17** [10] 324 (1938). M.D.

Milling porcelain enamel. J. E. HANSEN. *Emaillerie*, **6** [7] 11–16; [8] 9–22; [9] 7–21; [10] 26–28 (1938). M.D.

Nature of inclusions in cast iron. F. W. SCOTT AND T. L. JOSEPH. *Metals & Alloys*, **9** [11] 299–302 (1938).—Typical gray irons were analyzed for oxide by the elec-

trolytic iodine method (*ibid.*, [7] 171–74; [8] 201–206), and the results were correlated with microscopic observations to give the following conclusions: tests cast in dry sand molds are contaminated by the sand; tests cast in cold graphite molds are satisfactory for analysis. The oxide residue is chiefly SiO_2 and FeO; the FeO percentage is controlled by the Si : FeO ratio. The FeO is so close to the equilibrium value that most of the FeO is present as such in solution and little is present as silicate. No support was found for the theory that graphitization depends on the presence of nonmetallic nuclei; no nodular graphite or irregularities were observed. The variety of crystalline shapes suggested the presence of different oxides, a possibility that should be studied petrographically. The oxygen content in all cases was low (0.0027 to 0.0059%).
F.P.P.

One cover coat ware. E. C. AYDELOTT. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 72–79.—Advantages to be derived in making a piece of ware in one coat are (1) a probable savings in enameling costs of 20 to 30%, increased resistance to chipping being built into the product by the decreased thickness of enamel, and (2) a noticeable increase in production capacity made possible by eliminating the second coat of white. Ware to be made in one coat should be designed for one-coat work; the iron must be of superior quality, the ground coat must be perfect, and the white frit should be as opaque as possible. F.J.Z.

Ornamental enamels. VIELHABER. *Emailwaren-Ind.*, **15** [50] 327–28 (1938).—Art enameling on copper is described. V. suggests the following formula for an enamel batch to which opacifiers can be added for white coloring or which can be ground with coloring oxides for colors: 25 quartz, 20 soda, 24 borax, 10 boric acid, 5 saltpeter, and 5 sodium fluosilicate. This batch is free from lead, melts easily, and can be worked or painted wet. M.V.C.

Prepared enamel clay. V. *Emailwaren-Ind.*, **15** [51–52] 337–38 (1938).—V. gives the composition of Westerwald clay which is best adapted for enamels and compares it with mixtures of other clays and bentonite. M.V.C.

Problems in milling and application of dry-process enamels. FRANK ZVANUT AND RALPH FRY. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 134–45.—Cleanliness and fineness are perhaps the most important responsibilities of the mill-room man. The need for standard test methods for determining the fineness of powders is pointed out. An efficient magnetic separator for the removal of iron particles from the powder is discussed, together with the need for greater control of the amount of powder applied to a casting to obtain maximum coverage. F.J.Z.

Reducing the borax content in enamels. VIELHABER. *Emailwaren-Ind.*, **15** [45] 296–97 (1938).—Borax in enamels serves two purposes: (1) flux and (2) solvent for metal oxides. Other materials can replace borax as a fluxing material, but no substitute for converting metals has been found. To make metal oxides harmless, a chemical combination as well as a physical dissolving must occur, *e.g.*, $Na_2B_4O_7 + FeO = Fe(BO_2)_2 + 2NaBO_2$. Silicic acid combines with metal oxides but a series of double silicates is formed and the reaction takes too long. The use of water glass as a substitute is not new; it has the disadvantage of hardening the mass unless the liquid water glass is neutralized with soda. P_2 can also be used, but it is problematical whether the desired conversion of the iron oxides is obtained in either case as it is with borax. See "Materials—," *Ceram. Abs.*, **18** [5] 122 (1939). M.V.C.

Relation of sheet-welding practices to certain porcelain enamel defects. J. J. CANFIELD AND A. E. TAYLOR. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 213–22.—Welding is defined as a process which provides intimate contact of adjacent parts by fusion or by plastic flow. Certain conditions of the metal left from the welding operation may directly or indirectly cause enamel defects such as hairlining, chipping, fishscaling, boiling, and copperheading. Characteristics of each are discussed, and several photomicrographs are included. F.J.Z.

Review of American literature on porcelain enamel. EMERSON P. POSTE. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 3–27.—P. covers the literature on porcelain enamel from April, 1937, through June, 1938, reviewing briefly 195 articles. See *Ceram. Abs.*, **18** [1] 12 (1939). F.J.Z.

Solvent degreasing in the plating industry. H. R. NORGREN. *Monthly Rev. Amer. Electroplaters' Soc.*, **25**, 731–39 (Oct., 1938); *Metals & Alloys*, **10** [2] MA 104 (1939).—The vapor-type degreaser does not remove insoluble matter from the surface. To accomplish this, the surface is sprayed with solvent at pressures of 25 to 30 lb./in.^{2} and in quantities of 80 to 120 gal./min. Solvent degreasers may be used in connection with automatic or semiautomatic plating systems. The solvent most commonly used is trichlorethylene, and it is stabilized against decomposition by proprietary substances. The average cost of cleaning by this method is 70¢ per ton of work.

Sources of enamel-shop waste. W. F. FINDLAY. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 89–95; see "Wastes—," *Ceram. Abs.*, **17** [1] 9 (1938). F.J.Z.

Tentative tests for abrasion resistance. W. N. HARRISON. *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 32–37.—A shop test may be satisfactory if it tells which of two specimens is better or whether a certain item in the production line is running about the same from day to day. A standard test, however, should enable an enameler to compare his results with those of another enameler. In the test for abrasion, the test sample is measured for specular gloss before and after the specimen undergoes a controlled abrasive scrubbing treatment. The percentage of the original specular gloss that remains is taken as the abrasion index. The abrasive medium is composed of a specified weight of standard feldspar abrasive, a standard weight of $^5/_{32}$ in. rust-resisting ball bearings, and 5 cc. of water. Six specimens can be tested at one time in a testing apparatus which fits into the Ro-Tap machine. Cast-iron wet-process enamels containing lead oxide were found to be the least resistant to abrasion by this test, while the acid-resistant enamels were found to be the most resistant. F.J.Z.

Vitreous enameling practice. S. HALLSWORTH. Read before Swansea Technical College Metallurgical Society, Feb. 26, 1938; abstracted in *Jour. Iron & Steel Inst.* [London], **138** [2] 155A (1938); see *Ceram. Abs.*, **16** [4] 111 (1937).

PATENT

Rustless iron. W. B. ARNESS. U. S. 2,150,901, March 21, 1939 (Feb. 1, 1938).—In a composition of matter, a corrosion-resisting alloy iron of good ductility, formability, and weldability, which is of improved stability and unsubstantially hardenable, comprises approximately 9 to 30 chromium, 5 to 15 nickel, 0.005 to 0.035 nitrogen, and 0.02 to 0.07% carbon, the remainder consisting of iron.

Glass

Again Ford shows the way. R. S. MCBRIDE. *Chem. & Met. Eng.*, **46** [3] 150 (1939).—M. describes the Twin City glass plant of the Ford Motor Co. and mentions some of the outstanding innovations, *e.g.*, mining of the sandstone directly beneath the plant, reversal of heating of the glass tank by pyrometer control instead of time control, an adjustable curtain wall suspended at the mid-point of the furnace so that it can be lowered to within 18 in. of the glass line to provide uniform heat distribution, briquetting of the feed, and automatic control with push-button

operation. Because of the low iron content of the sandstone it is necessary to add some iron oxide to the batch so that the finished glass will absorb a sufficient amount of the actinic rays of the sun, thus protecting the plastic, which is of the vinyl type. B.C.R.

Armor glass. ANON. *Manchester Guardian Commercial*, **36**, 156 (1938); abstracted in *Kunststoffe*, **29** [1] 23 (1939).—Wire gauze is replaced by threads of polyvinyl alcohol in a new flat glass which can be used in the same manner as wire glass. It is insensitive to temperature, and adhesion between the glass and fibers is better than that between glass and wire. The fibers can be colored. D.A.B.

Arsenic in the glass batch. F. H. ZSCHACKE. *Glashütte*, **68** [35] 607–609 (1938).—Arsenic is one of the most important refining and decolorizing agents for glass, but its action has not been fully elucidated by research. The following facts have been ascertained: (1) arsenic alone in the glass batch does not act as an effective reduction agent; (2) in the finished glass it is present partly in the pentavalent form, whereas at the beginning of fusion it is in the trivalent state; oxygen has been taken up; (3) with longer heating time the amount of pentavalent arsenic in the glass batch diminishes, and the trivalent arsenic content increases; and (4) arsenic is a strongly oxidizing agent with the formation of arsenic + arsenic pentoxide, but it may decompose, and the liberated arsenic may absorb oxygen again and become arsenic trioxide: $5As_2O_5 \rightarrow 3As_2O_5 + 4As$; $4As + 3O_2 \rightarrow 2As_2O_3$. This arsenic trioxide is converted by an oxygen distributer, usually saltpeter, into arsenic pentoxide ($As_2O_3 + O_2 = As_2O_5$). Arsenic alone does not give satisfactory results in refining; excess oxidizing agent must be present. A brief explanation of the action of lump arsenic is given. Very small amounts of arsenic (0.3 to 0.7 kg. to 100 kg. glass) suffice for refining glass because of the great expansion of gas volume at high temperatures. M.V.C.

Automatic acid polishing plant. RUDOLF HOHLBAUM. *Glashütte*, **68** [37] 649–52 (1938).—The characteristics and operation of the acid polishing plant are described. M.V.C.

Chemical analysis of glass. MICHAEL B. VILENSKY. *Jour. Amer. Ceram. Soc.*, **22** [5] 168–70 (1939).

Continuous sheet glass annealing lehr. A. W. PISHTA. *Ind. Heating*, **5** [12] 1128–32 (1938); **6** [3] 214–18, 226 (1939).—The Amsler-Morton annealing lehr in the glass plant of the Ford Motor Co. is described in detail. The sheet glass produced has a composition of 72.0 SiO_2, 0.1 Fe_2O_3, 0.6 Al_2O_3, 10.1 CaO, 4.2 MgO, and 13.0% Na_2O. Sheets are drawn vertically from a molten pool at 2050°F. By means of 19 thermocouples a definite temperature schedule is maintained in the lehr. M.H.

Dielectric constants of various types of glasses. W. HACKEL. *Physik. Z.*, **37**, 160–62 (1936).—The Baretter method (described by O. Neese, *Ann. Physik*, [5] **8**, 929 (1931)) was used for determining the dielectric constant of four Jena glasses at wave lengths of 12,000 to 10 meters. The accuracy of the electrical-conductivity measurements is approximately 2%, and that of the dielectric constant, approximately 0.5%. The compositions of the glasses are as follows: (1) $SiO_2 \cdot B_2O_3 \cdot Al_2O_3 \cdot Na_2O \cdot CaO \cdot F \cdot As_2O_3$; (2) $P_2O_5 \cdot K_2O \cdot B_2O_3 \cdot Al_2O_3 \cdot MgO \cdot As_2O_3$; (3) $SiO_2 \cdot B_2O_3 \cdot Al_2O_3 \cdot K_2O \cdot F \cdot As_2O_3$; (4) $SiO_2 \cdot Al_2O_3 \cdot P_2O_5 \cdot CaO \cdot BaO \cdot FeO \cdot B_2O_3$. Glass 4 has lower losses than Minos glass, which has been used extensively for condenser construction in high-frequency work. The dielectric constants are as follows:

Glass	85 m.	42.5 m.	32.3 m.	10.6 m.
1	5.73	5.63	5.49	5.47
2	6.31	6.29	6.25	6.20
3	5.74	5.72	5.72	5.70
4	4.69	4.65	4.65	4.65

Several diagrams show conductivity *vs.* frequency. The conductivity increases at first proportionally with frequency, but with shorter wave lengths the curves deviate from the straight line, *i.e.*, the conductivity increases less rapidly. See *Ceram. Abs.*, **17** [10] 326 (1938). L.E.T.

Effect of annealing on the density of borosodium glasses. M. FOEX. *Compt. Rend.*, **208** [4] 278–80 (1939).—Glasses made from calcined borax ($2B_2O_3 \cdot Na_2O$) and boron anhydride or sodium carbonate were melted at 1100°C under atmospheric pressure in a Pt crucible. After the density was determined (in xylene), the glasses were annealed at a temperature at least 50° higher than their respective transformation points and left for a week at this temperature; they were then cooled slowly (at a rate of 0.8°/hr.). This treatment did not modify the density; equilibrium was attained in all cases. Curves show the behavior of the different glasses and the increase in the specific volume as a function of the alkali content. Boric anhydride shows the greatest change in volume on heating (2.82%), which then decreases up to 21% Na_2O where it remains about constant (about 0.5%). M.H.

Effect of solubility of glass on behavior of the glass electrode. DONALD HUBBARD, EDGAR H. HAMILTON, AND ALFRED N. FINN. *Jour. Research Nat. Bur. Standards*, **22** [3] 339–49 (1939); R.P. 1187. Price 5¢.—Application of an interferometer method previously used for determining the relative solubility of optical glasses to a glass which is commonly used for making glass electrodes gave results leading to the following conclusions: (1) the solubility increases rapidly as the p_H of most solutions increases above 8.5 or 9; (2) at all values below p_H 7 for the solutions investigated (except 10 *N* H_2SO_4), the glass exhibits a slight swelling; (3) the rate of swelling is repressed in the acid region beyond p_H 2; and (4) at intermediate p_H values 3.1 to 4.0, the rate of swelling is repressed by high concentrations of magnesium sulfate. These regions of marked solubility change correspond to the regions of pronounced voltage departures exhibited by electrodes made from this glass. That the anomalies of the glass electrode are definitely associated with the solubility of the glass has been further demonstrated both by the use of glasses which do not exhibit swelling in the acid range (hence no detectable change of swelling in the "superacid region") and by measurements made in alkaline solutions, such as aqueous ammonia, in which soluble silicates are not formed. Under these circumstances, the voltage departures are greatly decreased or completely eliminated. For every case investigated, voltage departures of the glass electrode have been found to be accompanied by changes in the solubility of the glass. R.A.H.

Electric melting of glass. Y. R. CORNELIUS. *Glass Ind.*, **19** [7] 267–71 (1938); see *Ceram. Abs.*, **18** [3] 71 (1939).

Electrical volume and surface conductivity of solid glass and the effect of sorption of water vapor on the latter. E. V. IVANOVA AND N. A. SHALBEROV. *Kolloid. Zhur.*, **4**, 157–79 (1938); *Chem. Abs.*, **33**, 2012 (1939).—On one side of a glass plate a circle of Ag and on the other side a similar circle and a ring of Ag around it were deposited. The ring was earthed, and the resistance between the circles was measured; this gave the volume conductivity. The plate was cut along a diameter of the circles, and the resistance was again measured; it included the conductivity of the freshly formed surface between the circles. The breaking was also carried out in an air-tight vessel. The volume conductivity of mirror glass was, at 18°, approximately 2.5×10^{-14} ohm^{-1} cm.$^{-1}$, and that of silicate crown glass immeasurably small. The surface conductivity of the latter was 10^{-10} to 10^{-11} ohm^{-1} at 40 to 50% relative humidity and very high in saturated vapor; it changed irreversibly at successive increases and decreases of humidity. It is so small that the adsorption layer of H_2O can not contain any NaOH from glass.

English looking-glass plates and their manufacture: III. R. W. SYMONDS. *Connoisseur*, **98** [419] 9–15 (1936).—S. discusses aspects of the actual manufacture. The blowing process consisted in blowing the glass into cylinders which were cut down the middle with forceps, laid on an "earthen table," heated gradually to open flat, and then annealed. Casting consisted in pouring the molten glass onto an iron table where it was rolled to even thickness. Following either of these processes the glass had to be ground to exact planeness, polished with

graded abrasives, and silvered or foliated. There were many hazards, and the whole process was expensive. From the time of Charles II to that of George I, looking glasses were made by specialists, but later they came under the cabinet makers' and upholsterers' trades. Illustrated. See *Ceram. Abs.*, **17** [8] 273 (1938). M.E.P.

Flexible glass. ANON. *Verre & Silicates Ind.*, **9** [34] 392–93 (1938).—The properties and uses of acrylic derivatives are given. M.V.C.

Glass as engineering material. ANON. *Times Trade & Eng.*, **44** [901] 36 (1939).—Recent advances in the use of a glass as a chemical engineering material have been made possible largely by means of new glasses and new methods of working them. The mechanical properties of glass have been improved to a degree which enables it to withstand severe conditions. The new glasses, of which the special Durobax, Osram, and Pyrex brands are typical, belong to the borosilicate class. They are characterized by a low coefficient of expansion and improved tensile strength, with high resistance to corrosion and abrasion. Large all-glass reaction vessels of complicated construction are being made where a high degree of purity in the product is desired; *e.g.*, 80-liter chlorination flasks can be obtained, fitted with all-glass stirrer, gas-feed, and distribution pipe and connections, which may be heated quite safely with an external flame. By a new technique in glassworking, it is possible to bore, turn, screw, groove, and otherwise work glass with a precision normally associated with metal working. Internal and external cylindrical surfaces may be ground with similar precision by the use of iron tools having a sintered surface layer of tungsten carbide. Glass tubing in lengths up to 15 ft. and $4^3/_4$ in. in diameter can now be made. The larger sizes withstand a pressure of 10 atm., and the smaller sizes, pressures up to 50 atm. Glass pipe is used for heat exchangers and liquor heaters, the glass being mounted inside a metal jacket, and the separate lengths being joined by 180° bends. Long continuous heating and cooling coils are made up to 3 ft. in diameter, with up to 150 ft. of tubing, providing 120 sq. ft. of surface for heat transfer. Glass-lined steel apparatus is widely used for chemical operations. Glass-lined stills, condensers, and receivers are also made, as well as glass-lined pipe. Glass-fiber mats for filtering gases and woven glass-cloth filters for liquids have high filtration rate, efficiency, and freedom from attack by corrosive vapors and liquids. The filtration of hot strong acids, such as sulfuric, is thus greatly facilitated. Glass silk has a high insulating power for both heat and cold. It can be supplied in various lengths and widths, as mattresses and blankets, and in a variety of made-up forms. Its thermal and chemical stability and incombustibility, together with the fact that it is nonhygroscopic and can be moved about at will, make it useful in chemical factories. A.B.S.

Glass and pottery in Ireland. ANON. *Times Trade & Eng.*, **44** [901] 24 (1939).—Considerable development has taken place in the manufacture of glass and pottery in Ireland. In 1931, the glassmaking industry was almost extinct, but it was revived and the Ringsend bottle works reopened in 1932. Sheet and plate glass have been produced, and safety glass for the motor industry has been manufactured in Dublin since 1936. Domestic pottery has been made at Arklow since 1934, and considerable extensions have been carried out at Carrigaline, where a factory has been manufacturing earthenware teapots, vases, etc., for some years. The value of earthenware, semiporcelain, and majolica production in 1937 was £57,363, as against £46,550 in 1936. Glassware production increased from £139,103 in 1936 to £198,723 in 1937. A.B.S.

Hard-metal tools in the working of glass. A. EWALD. *Glashütte*, **68** [23] 387–90 (1938); see *Ceram. Abs.*, **16** [7] 194 (1937). M.V.C.

Heat-resistant and HF-resistant coating for show glasses. H. BECK. *Kunststoffe*, **28** [8] 69–70 (1938).—Luvican, dissolved in an organic solvent such as benzene, dichlorobenzene, or methylene chloride and applied to glass, forms a protective layer on glass apparatus and bottles which is transparent, adhering, and resistant to heat and hydrofluoric acid. D.A.B.

Important improvements in fused-quartz mercury arcs. L. B. JOHNSON AND S. B. WEBSTER. *Rev. Sci. Instruments*, **9** [10] 325–27 (1938).—Five new a.-c. mercury arcs between oxide-coated tungsten electrodes in fused quartz are described, and the spectral intensity of each lamp is tabulated. Several points of superiority over the familiar mercury-pool cathode types are discussed. H.E.S.

Manufacture of selenium rose and selenium ruby: I–II. HEINRICH PONGRATZ. *Glashütte*, **68** [17] 299–300; [19] 327–29 (1938).—There are two kinds of selenium glasses: (1) glasses colored with selenium alone (rose) and (2) glasses colored with selenium and admixtures of cadmium or sulfur (ruby, orange, yellow, etc.). In pure selenium glasses selenium can color the glass (1) in colloidal form dissolved directly as an element in the glass, giving it the rose color, or (2) as selenide combined with alkali in solution, coloring the glass yellow to brown. The difference in coloring of selenium is caused by changes in the rate of cooling (Fenaroli); rapid cooling gives rose and slow cooling produces yellow to brown. The action of selenium in glass lies within certain limited quantities, and higher additions do not deepen the color ("Carbon—," *Ceram. Abs.*, **14** [5] 110 (1935)). Arsenic gives a deeper color with selenious acid soda than with metal selenium in a lime glass of 30 soda, 40 potash, 20 lime, and 75 sand. Potash-lime glasses give a deeper rose than soda-lime glasses. The addition of saltpeter to glasses colored with selenious acid soda deepens the color. The smelting of a selenium ruby glass requires a most exact knowledge of the furnace, and P. recommends putting the glass frit containing selenium into the furnace as hot as possible. This produces a better color, and the glass fuses well throughout so that it is free from bubbles and seeds. In regard to the effect of furnace atmosphere on glasses containing selenium, research has shown that (1) a neutral or weakly oxidizing medium gives rose-colored glasses; (2) a change to reducing atmosphere gives brown; (3) with a strongly oxidizing medium the upper part of the melt is colorless; and (4) a similar colorless layer appears when the atmosphere is strongly reducing. The sequence of colors produced by proceeding from an oxidizing to a reducing medium is colorless, rose, brown, colorless. The change of color of selenium glasses through oxidation and reduction takes place the more easily (1) the higher the concentration of the oxidizing or reducing medium, (2) the smaller the resistance of the selenium preparation introduced, (3) the longer the melting time, (4) the smaller the selenium concentration, (5) the higher the temperature of the glass, and (6) the more rapid the flow of the glass and the less deep the glass bath. According to Höfler, an understanding of the rose coloring by selenium is not to be found in the field of colloid chemistry. In a tank furnace the following glass batch gives good selenium rose coloring: 100 sand, 30 soda, 6 potash, 16 lime, 3 saltpeter, and 0.8 kg. arsenic with 170 g. selenium. To obtain the same coloring in a furnace with overhead flame, which is more difficult, the batch must be changed to 100 sand, 23 soda, 10 potash, 16 lime, 4 saltpeter, 2 borax, and 1 kg. arsenic with 185 g. selenium and 0.4 g. cobalt oxide. Glasses with selenium and cadmium or sulfur additions (ruby, yellow, orange selenium) are discussed. A selenium ruby (also known as selenium signal glass) is a glass with dark-red coloring used in the manufacture of reflectors (massive and flash glass). The research of Weckerle on selenium coloring (*ibid.*, **15** [11] 329 (1936)) and of Springer is described. The assertion that zinc oxide is the most important constituent of selenium ruby glasses was proved to be not altogether correct. The compositions of selenium ruby, selenium yellow, opaque selenium glasses, and orange glasses and the conditions under which optimum results are obtained are given. M.V.C.

Mirror making. ANON. *Glashütte*, **68** [41] 713–16 (1938).—The chief methods of manufacturing mirrors are reviewed. M.V.C.

Relation between viscosity of glass and temperature.

SCOHY. *Bull. Soc. Chim. Belg.*, **47** [12] 889–932 (1938).—From results of experiments with 22 glasses, S. found that the viscosity can be expressed as a function of the reciprocal absolute temperature by three straight lines, each extending over a different temperature range, by the formula $\log \mu = a + \frac{10^b}{T}$ or $\mu = AeB/T$, where A and B are material constants. The complete measurements and their evaluation are given. M.H.

Ring-section examination of glass containers. V. C. SWICKER. *Bull. Amer. Ceram. Soc.*, **18** [4] 143–47 (1939).

Silicate glass in ultra-high frequency fields. A. KHARKOV AND K. VODOPYANOV. *Zhur. Tekh. Fiz.*, **8** [10] 910–14 (1938); abstracted in *Physik. Ber.*, **19** [24] 2525 (1938).—The dielectric losses of quartz-silicate glasses (pure and with additions of Na_2O and PbO) were investigated as a function of the frequency (in the range 1.7 to 35 megacycles), temperature, and structure of the glass. The loss is independent of frequency; it increases strongly with increase in percentage of Na ions and slightly with increase in percentage of Pb ions. The loss depends on the structure, decreasing with the heat-treatment and temperature applied to the glass. A type of glass was found in the course of the experiments (designated No. 50) which has a loss of only 2 min. (expressed in electrical degrees) and is independent of frequency and (up to 300°C) temperature. This glass is recommended for radio technique. M.H.

Stained glass in Ireland. ANON. *Times Trade & Eng.*, **44** [901] 18 (1939).—Stained glass, sculpture, and church decoration are of great importance in Ireland where the people are deeply religious. Not many years ago cheap German or Italian products of a crude and inartistic type were imported for church decoration. The Harry Clarke Studio in Dublin (established in 1886) has a wide reputation through the distinctive work of the founder, who was an artist with great individuality. Since his death in 1930, the studio has supplied windows for churches in Great Britain, America, Australia, Africa, and India. A good example of its later work is the Kevin Barry Memorial Window, designed and executed by R. J. King for University College, Dublin. Another example is the window made for the World's Fair in New York. The Waterford cut-glass industry has died out, although glass bottles and sheet glass of a more ordinary commercial character are manufactured in Dublin. A.B.S.

Standards for testing glass surfaces. K. H. BORCHARD. *Sprechsaal*, **71** [37] 463–67 (1938).—B. discusses the testing of glass surfaces against inner pressure. M.V.C.

Testing glass for strain. G. SCHIEB. *Österr. Glaserztg.*, **2**, 61–62 (1937).—Strains in glass can arise from unsatisfactory annealing or from faulty mounting in glazing. Simple devices are available for detecting strains. A device made by Zeiss consists of a black plate as polarizer with an adjustable arm carrying the analyzer. Illustrated. J.F.H.

Thermolux glass in modern industry. ANON. *Verre & Silicates Ind.*, **9** [32] 367–69; [36] 413–17 (1938).—Thermolux is a new type of insulating and light-diffusing window glass used in factories. It is a sandwich glass produced by the Glaces & Verres Co. (Glaver, France) and is composed of (*a*) two sheets of thick durable clear glass, (*b*) an intermediate layer between the sheets composed of a special fabric of glass silk, spun very fine and woven at a definite angle; and (*c*) a special cement which seals the clear glass hermetically, resists heat, cold, humidity, etc., and acts as protection in case of rupture. The glass silk intermediate layer is not to be confused with glass wool; it has higher insulating properties because the tiny air spaces between the threads are enclosed between two glass panes and kept absolutely immobile. The value of the coefficient of thermal conductivity depends on the thickness of the glass silk, which varies between 1 and 3 mm. The prismatic effect of the glass silk prevents direct sun rays from entering and reflects up to 80% of the heat rays, while the light entering is uniformly diffused, which gives better visibility than clear glass. Tests on the diffusion of light by Thermolux glass and ordinary glass made by the Department of Scientific and Industrial Research (London) and the National Physical Laboratory (Teddington) are given. See *Ceram. Abs.*, **18** [5] 126 (1939). M.V.C.

SEPARATE PUBLICATION

Report on the Glass Industry in West Virginia. Bureau of Industrial Hygiene, West Virginia State Health Department, 1938. 5 tables, 54 pp.—The following subjects are discussed: (1) nature and purpose of the study, (2) size of plants, (3) welfare data, (4) materials used, (5) typical glass batches, (6) health hazards and control measures, and (7) occupations. A description of decorating processes is given which includes (*a*) sandblast cutting, (*b*) glass cutting, (*c*) needle etching, and (*d*) plate etching. Glass decorating methods are as follows: (1) rubber stamp method, (2) ice decoration, (3) binding, lining, and painting, (4) steel plate transfers, (5) luster decorations, (6) metallic decorations, (7) decalcomania transfer, (8) silk-screen process, and (9) firing of the ware. The processes of manufacturing pressed prism glass and bent glass are given. West Virginia glass plants are listed.

PATENTS

Apparatus for decorating glassware. G. W. MEYER AND S. E. SHACKELFORD. U. S. 2,152,356, March 28, 1939 (March 14, 1938).

Apparatus for forming glassware. H. A. WADMAN (Hartford-Empire Co.). U. S. 2,151,876, March 28, 1939 (Jan. 18, 1934).

Apparatus for forming glassware. W. L. WAGNER, SR. U. S. 2,152,754, April 4, 1939 (July 26, 1937).—Apparatus for forming shallow ware from glass nappies.

Apparatus for handling bottles and jars. C. A. HEYNE (Owens-Illinois Glass Co.). U. S. 2,154,126, April 11, 1939 (May 11, 1937).

Apparatus and method of forming mineral wool from fusible solids. C. R. BUSS. U. S. 2,153,739, April 11, 1939 (Dec. 10, 1936).

Apparatus for tempering glass. W. B. CLITHEROW (American Securit Co.). U. S. 2,151,266, March 21, 1939 (Sept. 16, 1936).

Automatic glass-blowing machine. P. J. SCHOONENBERG AND J. J. HARDENBERG (N. V. Mij. tot Exploitatie van Uitvindingen). U. S. 2,153,485, April 4, 1939 (Sept. 22, 1934).

Centrifugal apparatus for making filaments of glass or other thermoplastic material. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M. B. H. (Hans Pink, inventor). Ger. 668,262, Nov. 29, 1938; 32*a*. 25; *Chem. Abs.*, **33**, 2303 (1939).

Ceramic mass. FRIEDRICH E. DÜRR. Ger. 666,699, Oct. 26, 1938; 80*b*. 21.06; *Chem. Abs.*, **33**, 2304 (1939).—A mass for plugging containing metal consists of fine steel wool mixed with a drying binding agent such as a mixture of anhydrous $CaSO_4$ and lime powder.

Cooling apparatus for tempering glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 502,065, March 22, 1939 (July 27, 1937).

Displacement glass feeder. PETER KUCERA (Hartford-Empire Co.). U. S. 21,037, March 28, 1939 (Nov. 18, 1936); reissue of original U. S. 1,997,799, April 16, 1935.

Glass-drawing tank. W. O. AMSLER (Frazier-Simplex, Inc.). U. S. 2,153,228, April 4, 1939 (March 29, 1937).

Glass-forming machine. C. W. STUDLEY (Liberty Glass Co.). U. S. 2,152,103, March 28, 1939 (May 14, 1937).

Glass-grinding tools. PILKINGTON BROS., LTD., AND J. H. GRIFFIN. Brit. 502,118, March 22, 1939 (Oct. 5, 1937).

Improvements in the production of tempered glass. CORNING GLASS WORKS. Fr. 831,122, Aug. 23, 1938; *Chem. Abs.*, **33**, 1900 (1939).—The thickness of the interior zone of the glass, which is in a state of tension, is regulated and is made greater if a higher state of compression in the surface layer is desired. A glass bar is heated to 800° and then subjected to an initial cooling of small intensity by maintaining the surrounding air at room temperature for

about 10 sec. The glass is then placed in a tempering bath at 330°, the bath comprising a eutectic mixture of $NaNO_3$ and KNO_3. The glass is then placed in a second bath of the same composition at 160°, removed after 30 sec., and cooled in air.

Laminated glass. W. H. Moss (Celanese Corp.). U. S. 2,153,585, April 11, 1939 (March 4, 1936; Feb. 4, 1937).

Lens blocking. L. F. Rowe (American Optical Co.). U. S. 2,151,233, March 21, 1939 (Jan. 21, 1937).

Luminous glass letter sign. Bartlett Vandermeer (Flexlume Corp.). Can. 380,029, March 14, 1939 (Jan. 14, 1938); see *Ceram. Abs.*, **17** [7] 250 (1938). G.M.H.

Machine for the manufacture of glass bottles. W. B. Mitchell. U. S. 2,151,864, March 28, 1939 (Nov. 20, 1935).

Making glass articles having optically accurate surfaces and articles produced thereby. Corning Glass Works. Brit. 501,865, March 22, 1939 (Feb. 5, 1937).

Making lenses. L. W. Goddu (American Optical Co.). U. S. 2,151,509, March 21, 1939 (May 13, 1935).

Making reinforced hollow slabs. W. H. Cobi. U. S. 2,153,741, April 11, 1939 (Dec. 14, 1936).

Melting glass. Hartford-Empire Co. Ger. 669,744, Dec. 8, 1938 (June 12, 1935); VI/32*a*. 1.—A method is described for melting glass in a tank furnace constructed with separately heated melting and refining chambers and a weir extending upward from the bottom of the tank. D.A.B.

Method and apparatus for decorating and annealing glassware. D. G. Merrill (Hartford-Empire Co.). U. S. 2,151,983, March 28, 1939 (Feb. 17, 1937).

Method and apparatus for producing glass vessels. Jakob Dichter. U. S. 2,151,840, March 28, 1939 (Jan. 24, 1935).—A machine has means for heating one end of a tube of relatively large diameter, means for engaging a tool with the heated end of the tube to form a shoulder thereon and a reduced extension which projects beyond the shoulder, means for heating the free end of the reduced extension of the tube and the end of a tube of smaller diameter, means for engaging the end of the tube of smaller diameter with the reduced extension of the first mentioned tube, and means for blowing the joint between the two tube sections into engagement with a mold.

Method and apparatus for spinning glass wool. Games Slayter (Owens-Corning Fiberglas Corp.). U. S. 2,150,945, March 21, 1939 (March 1, 1934; renewed June 3, 1938).

Nonglare headlight. Alexander J. Winter. Can. 379,983, March 7, 1939 (Oct. 19, 1937). G.M.H.

Nonsplintering glass. I. G. Farbenind. A.-G. (Gerhard Balle and Karl Daimler, inventors). Ger. 668,445, Dec. 3, 1938; 39*b*. 27; *Chem. Abs.*, **33**, 2303 (1939).—As adhesives in the manufacture of nonsplintering glass, use is made of mixtures of cellulose derivatives or their solutions with the condensation products obtainable, as described in Ger. 638,393 (*Ceram. Abs.*, **16** [10] 301 (1937)), from maleic anhydride (or reagents which yield it) and certain aliphatic alcohols. Examples are given.

Plate glass surfacing table. A. L. Harrington (Pittsburgh Plate Glass Co.). U. S. 2,152,801, April 4, 1939 (March 29, 1938).

Producing glass wall plates with colored and translucent mortar joints. Bruno Grossmann. Ger. 665,492, Sept. 8, 1938 (July 13, 1937); VI/80*b*. 14.02.—An artificial resin solution mixed with SiO_2 is applied to the matted side of the glass, and the mixture is allowed to harden. A second coating is applied and this is sprinkled, while still soft, with finely pulverized SiO_2 and dried. D.A.B.

Production of fibers or threads from glass, slag, etc. L. von Reis (N. V. Mij. tot Beheer en Exploitatie van Octrooien). U. S. 2,152,423, March 28, 1939 (Dec. 15, 1934).

Reflecting unit. Emilio Pascucci (Corning Glass Works). U. S. 2,151,279, March 21, 1939 (May 25, 1934).

Structural Clay Products

Action of lime in brick clay. W. Marschner. *Erde & Stein*, **5** [1] 3–8 (1937).—Limestone in brick clay is harmful when present in lumps on account of its hydration after firing. This damage may be prevented by washing, disintegration by roller mills, dry and wet pans, the Heuer process (mixing with combustible matter), or dipping after firing. Lime causes earlier vitrification and a pale color. The color may be improved by the addition of coloring oxides or by the application of an engobe. Sulfur oxide in the kiln gas influences the color by converting the carbonate of lime into the sulfate and by the formation of soluble salts which may discolor the finished product; this can be prevented by a reducing firing. W.K.

Brick test roads under traffic. F. E. Swineford. *Dependable Highways*, No. 162, pp. 3–11 (1939).—A comparison of the service obtained with various methods of constructing brick pavements acts as a guide for improving construction methods. By using merited construction features in test roads under traffic, additional useful design information is acquired. Structural details of a longitudinal brick project, the second of its kind in Ohio, are described. A reinforced grout-filled block pavement constructed of 8 x 8 x 3¾ in. vitrified paving block with ⅜ in. round bars grouted into each joint is a possible satisfactory method of resurfacing existing stable bases. A monolithic vitrified brick project constructed with modern finishing machinery is also described. Illustrated. P.S.D.

Materials for sewerage pipes. Felix Singer. *Brit. Clayworker*, **47** [562] 353–60 (1939).—S. reviews previous literature, states the requirements for pipes in regard to resistance to acids, salts, and water, and compares the relative merits of cement and stoneware pipes. R.A.H.

Soluble salts in heavy clay products and their determination. H. Hecht. *Tonind.-Ztg.*, **63** [1] 4–7 (1939).—H. reports on the present knowledge of the problem of soluble salts and brings out the important facts. The sulfates of sodium and magnesium are the main troublemakers. An appearance of scum depends as much upon the structure of the brick and its location as upon the amount of soluble salts present. Practical tests for scumming and methods for the quantitative extraction of soluble salts are discussed. W.K.

Workability of clays. Robert P. Graham and John D. Sullivan. *Jour. Amer. Ceram. Soc.*, **22** [5] 152–56 (1939).

PATENTS

Brick and tile. Xavier Schedel. Ger. 665,225, Sept. 20, 1938; 80*b*. 9.04; *Chem. Abs.*, **33**, 1901 (1939).—Clay is mixed with peat refuse which has been pretreated with an aqueous solution of a saponified resin and (or) pitch, and the mixture is molded, dried, and fired in the usual way. The products can be nailed.

Building brick or block. T. O. Raad. U. S. 2,151,798, March 28, 1939 (June 8, 1937).

Building tile. N. A. Noce. U. S. 2,154,213, April 11, 1939 (April 15, 1937).

Coping. C. H. Miller (Universal Sewer Pipe Co.). U. S. 2,153,308, April 4, 1939 (Nov. 18, 1937).

Manufacture of brick, tile, etc. E. B. Jones. Brit. 501,746, March 15, 1939 (Sept. 2, 1937).

Refractories

Action of clinker on refractories. G. V. *Argile*, No. 190, pp. 17–19 (1939).—Clinker appears as a rather light metallic sponge, a compact lava, or a combination of both and becomes very hard when cold. Crystallization occurs the most often, but sometimes, with rapid cooling, a vitrification is produced. At high temperatures, clinker attacks the grate (it forms new ferrous silicates which facilitate the fusion of the mass) and it also reacts on the

refractories. The radiation of the heated walls raises the temperature of clinker which, in contact with refractories, acts as flux. Fusible cinders melt and run down without adhering; less fusible cinders stick and form stalactites. They penetrate the joints, soak into the brick, corrode it, and wash it away. The conditions of corrosion of refractories depend on the twelve combinations of the ternary system lime–alumina–silica. The effect of porosity and the rate of running off of the film of cinders on the refractories was studied by Fehling (*Ceram. Abs.*, **17** [8] 280 (1938)), and Fehling and Rosin showed that porosity increases corrosion to a great degree; compactness of the brick and well-fitted joints are, therefore, fundamental requirements for avoiding the penetration of scoria and the destruction phenomena of refractories. Because of their careful manufacture, silica brick of good quality hold up well in the firing zone, but several rows of silicon carbide brick (to which clinker does not adhere), extending up to the height of the grate, stand the great abrasive action of the combustible better than silica brick and will lengthen the life of the silica-brick lining above. In choosing a fuel, that which gives the purest analysis is not the most desirable if its cinders are fusible. To improve the fusing point of cinders, the addition of a powdered mixture of manganese dioxide, alumina, and lime to the coal is suggested. This mixture liberates oxygen during fusion and increases combustion; the alumina mixes with the cinders and slows down the production of clinker by augmenting the fusibility temperature of the cinders; this prevents their melting in a thin sheet and sticking to the walls. The lime displaces the bases combined with the silica and alumina, and dangerous double silicates of iron and lime are not formed. M.V.C.

Action of heavy oil on refractories in combustion chambers. G. V. *Argile*, No. 187, pp. 17–19 (1938).—According to M. A. Minne (*Rev. Combustibles Liquides*, June–July, 1938), the destruction of the refractory wall is generally caused by the formation of a fusible soda silicate. The refractories contain silica and practically no soda, but heavy oil normally contains traces of soda and sulfuric anhydride which, when oil is burned in quantities, combines with the silica in the refractories and explains theoretically the violent attack on refractory chambers. Since it appears impossible to change the composition of oils and lessen their aggressive effect on refractories, other possible solutions to the problem are (1) the use of superrefractories, (2) surface protection of exposed parts, (3) improvement in the quality of ordinary refractories, and (4) improvement of joints. Resistance to corrosion and resistance to temperature variations and thermal shock are two irreconcilable factors, and this is the reason for the relative failure of some products. A decrease in the proportion of binding clay and porosity is needed for bettering refractories. The width of the joints must also be minimized. Another problem is the construction of combustion chambers with improvements for (1) increasing radiation, (2) cooling walls, (3) introducing combustion air in the chamber in such a way that it forms a screen between the flame and the wall, and (4) avoiding an extremely high temperature which melts refractories. See *Ceram. Abs.*, **17** [8] 280 (1938). M.V.C.

Chromite-magnesite concrete for the hearthstone of heating furnaces. I. L. Movshevich. *Vestnik Inzhenerov Tekh.*, **1938**, No. 7, pp. 435–36.—For the hearthstones of heating furnaces, silica, grog, magnesite, and talc materials are generally used, but they are not completely suitable for the purpose. A. I. Kramarenko, L. A. Zeitlin, and S. D. Radchenko (Ukrainian Scientific Research Institute of Refractory and Acid-Resisting Materials) studied the possibility of selecting the most rational batch which would guarantee the production of a material possessing a high stability against slag, a high temperature of deformation under load, and a good mechanical strength. Chromite-magnesite concrete with an addition of aluminous cement was used. Conclusions are as follows: (1) the chromite-magnesite concrete used in metallurgical furnaces is not scorified; (2) it permits quick repairs at 300° to 500° and the immediate forced reheating of the furnace; (3) it eliminates contamination of the metals by sand and irregular heating of the ingot; and (4) slag obtained from heating furnaces using this concrete, by its chemical composition, is almost a pure dross. B.E.K.

Clarkdale method of hot-patching operating furnaces. C. R. Kuzell. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 995; *Metals Tech.*, **6** [2] 12 pp. (1939).—Most older methods of patching weak spots and burned-out zones in furnaces have involved replacement of masonry by refractory shapes in such areas, a procedure with many obvious disadvantages. The method developed at the Clarkdale smelter of Phelps Dodge comprises renewing the interior refractory surfaces of operating furnaces by pneumatic spraying of an aqueous suspension of finely divided refractory particles. The method has been used successfully for patching the arches, side walls, and uptakes of reverberatory furnaces for copper smelting but may be applied as well to other types of furnaces, such as open-hearth steel furnaces, glass furnaces, etc. The projecting equipment consists of a storage or pressure tank to hold and expel the slurry and a spray pipe with a suitable tip. Wear of the tips is the most serious wear on the equipment. Campaign tonnage of over a half million tons has not been unusual; the cost of this method of patching increases with the age of the campaign and depends also on local conditions, *i.e.*, price of powdered refractories, labor, compressed air, etc. The working conditions with the new method are infinitely better than those with the old. F.P.P.

Desulfurization of pig iron by sodium carbonate. N. Theisen. *Stahl & Eisen*, **58**, 773–79 (1938).—T. gives the metallurgical, chemical, and thermochemical results of the use of sodium carbonate in desulfurization of pig iron; the life of ladles declined to half, following the use of sodium carbonate. Changing the lining to one of rammed dolomite and magnesite gave results which were little better. Experiments are being continued. The soda also corrodes the pig-iron mixer. L.R.B.

Developments in the refractories industry, 1937–1938. Anon. *Refrac. Jour.*, **15** [2] 55 (1939).—A general review is given. 26 references. B.C.R.

Developments in special refractories. F. Harders. *Stahl & Eisen*, **58**, 1081–85 (1938).—31 references. See "Forsterite—," *Ceram. Abs.*, **14** [7] 166 (1935); "Experiments—," *ibid.*, **16** [1] 21 (1937); "Mixtures—," *ibid.*, [10] 304. L.R.B.

Effect of boron oxide, phosphorous pentoxide, and ferric oxide on the thermal expansion of a Florida kaolin-quartz mixture. C. L. Thompson and C. W. Parmelee. *Jour. Amer. Ceram. Soc.*, **22** [5] 170–72 (1939).

Erosion of refractories by coal slag. H. R. Fehling. *Jour. Inst. Fuel*, **11** [59] 451–58 (1938).—The action of coal slag on refractories can be considered as a process of solution in spite of the chemical reactions which precede or accompany it. The striking acceleration of erosion with temperature is due to the threefold effect of increasing solubility, decreasing viscosity, and accelerated diffusion. The following recommendations are made for further research: (1) viscosity of coal slag as related to composition and temperature, (2) solubility of the more important refractory materials in typical coal slags, (3) study of diffusion, and (4) measurement of erosion under strictly defined operating conditions. See "Attack—," *Ceram. Abs.*, **17** [8] 280 (1938). H.E.S.

Experiments for the production of alumina. M. Paschke. *Rundschau Deut. Tech.*, **18** [44] 4 (1938); *Chem. Abs.*, **33**, 1887 (1939).—From poor raw material, *e.g.*, clay, slate, or blast-furnace slags, alumina can be produced by fusion with Na_2CO_3. Curves show the yield of Al_2O_3 (ratio between Al_2O_3 contained in the Na aluminate solution and Al_2O_3 really contained in the sintered material) and the SiO_2 solubility (proportion of SiO_2 to Al_2O_3 of the aluminate solution) in relation to Na_2CO_3 and CaO used. When $Na_2O:Al_2O_3$ is about 3.0, a maximum yield of 66% is attained, while the minimum of the SiO_2 solubility remains at 2.5% as long as $Na_2O:Al_2O_3$ remains below 2.5. Practically the best results are obtained from raw ma-

terials in which the proportions $CaO:SiO_2$ and $Na_2O:Al_2O_3$ are between 1.8 and 1.9, yielding 50 to 60% alumina with a SiO_2 content of 2 to 5%. The sintered material is leached with hot water, and the resulting aluminate solution is then converted into alumina by one of the methods used for the decomposition of bauxite. The leached residue is a kind of blast-furnace cement, but with up to 7% alkalis. While for the production of Al_2O_3 the SiO_2 must be removed from the aluminate solution, it is also possible to precipitate it together with the alumina, yielding a product that can be used for the manufacture of Al-Si alloys.

Extraction of alumina from raw materials high in alumina: II–III. S. NAGAI AND J. KATAYAMA. *Jour. Soc. Chem. Ind. Japan*, **41** [4] 106B; [8] 253–54B (1938).—Further studies on the extraction of pure alumina from diaspore clayey materials of high alumina content from Manchukuo and North China are described. The sample of diaspore clay used in the tests had the following chemical composition: loss on ignition 14.9, SiO_2 20.3, Al_2O_3 59.8, TiO_2 2.1, Fe_2O_3 2.0, CaO 0.1, and MgO 0.5%. The sample was pulverized and mixed with powdered calcium carbonate (*S*) and sodium carbonate (*N*) in various proportions. The best result was obtained by heating the mixture clay 40, *S* 20, *N* 40 at 1250°C for 1 hr. and extracting with hot water. About 91 to 93% alumina was extracted. Clay samples of the same composition were mixed with *S* and *N* in proportions which differed from those used in the foregoing tests; the extraction solutions also differed. The best results in this case were obtained by heating the mixture clay 40.38, *S* 48 to 50, *N* 10 parts at 1300° to 1350°C for 1 hr. and boiling with 2% sodium carbonate solution. Alumina in the amount of 94 to 95% was extracted. See *Ceram. Abs.*, **16** [11] 340 (1937); for Part I see *ibid.*, **17** [5] 186 (1938). M.V.C.

High-temperature melting with an electron bombardment furnace. R. HULTGREN. *Ind. Heating*, **6** [3] 203–206 (1939).—The electron bombardment furnace is used to melt very small quantities of metals of high melting point in a vacuum; the temperatures attainable are limited only by the refractoriness of the crucible, *e.g.*, a zirconia crucible will withstand 2500°C. The principle of operation is a hot filament placed near a conducting crucible shell in a vacuum charged to high voltage (2200 v. in an example). Electrons fly from filament to shell, striking the latter; by liberating their energy they heat it up; no insulation is used, and the transformation of electrical energy into heat is perfect. With an expenditure of only 700 watts, a heat of 2850°C (5162°F) was obtained. Practical furnace arrangements are described. M.H.

Increasing roof life of open-hearth furnaces. A. GABDIN AND I. VAĬNSHTEĬN. *Teoriya & Prakt. Met.*, No. 6, pp. 17–19 (1938).—Due to the cooling influence produced by the charging doors, most of the hot gases in the furnace were deflected toward the rear wall and through the rear downtake. As a result of this, the roof over the rear downtake failed earlier than the rest of the roof. The life of the roof over the rear downtake was prolonged by increasing, somewhat, the dimensions of the front downtakes but by keeping the same dimensions for the rear downtakes. B.Z.K.

Induction furnaces for rotating liquid crucibles. E. P. BARRETT, W. F. HOLBROOK, AND C. E. WOOD. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 986; *Metals Tech.*, **5** [8] 12 pp. (1938).—When a vessel containing a liquid is rotated, the inner surface of the liquid takes the shape of a paraboloid under the simultaneous action of centrifugal force and gravity. Melted Wood's metal was poured into cylinders $2^1/_2$ in. in diameter, which were rotated at 180, 300, and 468 r.p.m. When the metal was solid, a slurry of plaster of Paris was added, and rotation was continued until the plaster had set. The following types of high-frequency induction furnaces using liquid-metal crucibles were constructed: (1) a furnace in which a graphite crucible packed in lampblack in a refractory tube was rotated concentrically within the coil; (2) a furnace in which a superrefractory crucible containing molten metal was rotated within a graphite-lined stationary cylindrical furnace; (3) a cylindrical furnace rotated as a unit. The second furnace was simplest to construct and the most flexible to operate, and it provided the smallest temperature gradient in the hot zone. Rotating liquid crucibles are slagproof and they eliminate contamination of the slag by the refractory; they are therefore well adapted to studies of slag-metal reactions. F.P.P.

Inversion of quartz to tridymite: XV–XVI. S. KONDO AND T. YAMAUCHI. *Jour. Soc. Chem. Ind. Japan*, **41**, [7] 221–22B (1938).—The microstructure of experimental silica brick made of Tamba quartzite and various mineralizers was studied. Sodium mineralizers are effective for tridymitization, while ammonium chloride and carbon are effective for cristobalization. Tridymite crystals develop particularly well in pores, just as the crystallization of natural minerals prevails in cavities of volcanic rock. The mineralizing action of ammonium chloride and carbon varies with the fineness of quartzite, *i.e.*, finer grains have a much greater action than coarse grains. Combined mineralizers seem more effective than single mineralizers. The microstructure of experimental silica brick made of Dairen quartzite and various mineralizers was also studied. The mineralizers showed the same effect as in the case of the Tamba quartzite, but the rate of inversion of the Dairen quartzite was lower. In order to augment the action of the mineralizers, Dairen quartzite must be ground finer than Tamba quartzite. **XVII–XVIII**. *Ibid.*, [8] 250–51B.—The thermal expansion of experimental silica brick made of Tamba quartzite and various mineralizers was studied; it was of minimum extent and was without marked abnormality. The results of linear thermal expansion tests on silica brick of Dairen quartzite are given; they are similar to those obtained for Tamba quartzite. For Parts **VI–XIV** see *Ceram. Abs.*, **17** [5] 200 (1938). M.V.C.

Jena glass for apparatus and new apparatus made from Jena glass. P. H. PRAUSNITZ. *Chem.-Ztg.*, **63** [12] 109–12 (1939).—P. gives a short history of glass for use in the laboratory as apparatus and the different chemical actions affecting glass. Glass apparatus and their characteristics are described. Forms of flasks, distillation apparatus, colorimeter tubes, vessels, apparatus with stirring attachments, glass electrodes for p_H determinations and potentiometric titrations, funnels, and filters are among the apparatus made from Jena glass. Illustrated. See "Laboratory—," *Ceram. Abs.*, **17** [8] 274 (1938). D.A.B.

Manufacture of melting pots. FRIEDRICH MERGLER. *Glashütte*, **68** [42] 729–32 (1938).—M. reviews the chief requirements for melting pots. The characteristics and data on raw materials used and the composition of mixes, rings, brick, etc., are given. M.V.C.

Olivine and its application as refractory. A. ESME. *Argile*, No. 191, pp. 5–13 (1939).—Olivine or peridot is a silicate of magnesia and a protoxide of iron of the general formula $Mg \cdot Fe(SiO_4)$ in which the proportions of MgO and FeO vary considerably. When iron is absent, the mineral is called forsterite, Mg_2SiO_4; when magnesia is absent, the mineral is fayalite, Fe_2SiO_4. Peridot is in the form of a vitreous transparent infusible substance, is hard, and is usually greenish, yellow green, olive green, or brown in color; it is rarely white. Crystallization is orthorhombic. Peridot is easily decomposed by HCl and, in finely powdered form, by acetic acid, forming a gelatinous silica residue. Under a blowpipe the magnesia variety becomes white without melting and therefore can be used as a refractory material. Peridot of Vesuvius has the following chemical composition: SiO_2 40.08, MgO 44.22, FeO 15.26. Varieties of peridot are given. The studies of Heindl and Pendergast on the large deposits of olivine in North Carolina are quoted (*Ceram. Abs.*, **13** [5] 119 (1934)). M.V.C.

Open-hearth furnaces. J. CARMANN. *Berg- & Hüttenmänn. Monatshefte Montan. Hochschule Leoben*, **87** [3] 49–58 (1939).—On the basis of actual data from open-hearth furnace operations, an exhaustive survey is made of those factors by which the melting capacity can be increased with simultaneous shortening of the melting time. The location and direction of the flame through the furnace

is determined solely by the construction of the furnace and not by the buoyancy of the flame which is only a small fraction of kinetic energy. Chromite-magnesite refractories have proved far superior to silica refractories; the softening point was not reached, even at the highest furnace temperature, and the heat conductivity was only about half (11,900 Cal./m.² hr. heat losses for silica against 5900 for chromite-magnesite). M.H.

Practical muffleless carburizing furnace. W. E. SANDERS, J. L. COYLE, AND W. A. DARRAH. *Metal Progress*, **34** [6] 678–83 (1938).—New gas carburizing equipment installed at Chevrolet's plant in Muncie is described. The furnace features an air-tight construction comprising several combustion chambers, each of which is connected to a downcomer flue by flexible seals. When repairs need to be made on any section of the furnace, the unit is merely shut off separately, disconnected, and replaced without the necessity of entering the furnace. Muffle repairs on conventional furnaces involve major reconstruction and long interruption of operation. Furnace walls are 13½ in. of special Fe-free refractories backed by 4½ in. of heat-resisting block, providing a graded insulated wall practically unaffected by temperature and carburizing gases. The carburizing of transmission gears in the furnace is described, and operating data comparing gas carburizing in this equipment with conventional pack hardening are given. F.P.P.

Production of high quality ball-gate and plug tubes for steel casting. I. L. MOVSHEVICH. *Vestnik Inzhenerov & Tekh.*, **1938**, No. 9, p. 562.—Requirements of plug and ball-gate tubes differ. Plug tubes should be refractory and slag resisting, and the ball-gate tubes should be thermally stable. Zhikharevich and Kogan (Ukrainian Scientific Research Institute of Refractory and Acid-Resisting Materials) studied the use of kaolin of Prosianoe (Ukraina, Donbass) for such tubes. The batch consisted of 30% grog, 80% primary kaolin, and 20% Chasov-Yar clay. The grog was mixed with 35% of Chasov-Yar clay and 35% Prosianoe kaolin and fired at 1380°C. The production process is described. B.E.K.

Recovery of alumina from clay, kaolin, and other silicic acid-bearing aluminum minerals compared with the aluminum sulfite method of the patent literature. WILLIBALD MACHU. *Metall & Erz*, **35**, 499–510 (1938); *Chem. Abs.*, **33**, 1888 (1939).—M. critically reviews the patent literature on the extraction of Al from ores high in SiO_2. These are best treated by extraction with H_2SO_3 or electrothermal reduction. Refractory ores should be digested under pressure in an autoclave to obtain high temperature without loss of SO_2. After extraction, steam is passed through the solution to drive out SO_2 and hydrolyze the sulfite, producing a precipitate of $Al(OH)_3$, which is rendered crystalline and easily filterable by the presence of small quantities of sulfite. The SiO_2 still present is removed by double precipitation. This method permits recovery of Al_2O_3 from the cheapest raw material, clay, by means of the cheapest acid, SO_2.

Refractories. J. H. PARTRIDGE. *Jour. Roy. Soc. Arts*, **87** [Jan. 13] 227–45; [Jan. 20] 254–77; [Jan. 27] 283–94 (1939).—In three lectures P. discusses the three groups of refractories, which, in modern practice, are substances retaining their stability at elevated temperatures. A refractory material must (1) have a high melting point, (2) be firm at high temperatures, and (3) be as chemically inert as possible. Group I includes the more or less plastic silicoaluminous products, or clay. Group II comprises the nonplastics to which a plastic bond is added. Group III comprises nonplastics without addition of permanent bonding agents; they are of more recent development and are more interesting from a purely scientific point of view. Only materials of a ceramic or earthy nature are included in these groups, not those of a metallic nature. The word "ceramic," commonly used in relation to pottery, comes from the Greek word "keramos," from an old Sanskrit root, meaning "to burn." Refractories, therefore, are products made from materials of an earthy nature, as distinguished from those of an organic or metallic nature, whose manufacture involves high-temperature treatment. The sixteen refractories in general use are given in a table with their melting points. Those most widely used and of the greatest commercial value are silica, kaolin, and fire clay; fire clay may be present alone or used in smaller proportions to make nonplastics capable of being molded. The chemical compositions of six English and two German fire clays are shown in a table. Clays are weathered products of silica rocks. They contain enough hydrated aluminum silicate to render them plastic when mixed with water. China clay is one of the purest; its theoretical formula is $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. After this clay is moistened with water and fired at high temperatures, its physical properties and appearance show differences not apparent from its chemical composition. P. discusses the atomic structure of clays with figures, tables, and theoretical build-ups. X-ray studies disclose two groups of clays: the first, of the kaolin type, contains about 40% alumina, and the second has a high proportion of silica to alumina. Five X-ray diffraction patterns of clay minerals show clays as built up of layers or sheets of hydrated silica or alumina. The structure of individual clays is the same. Their differences lie in the order and relative proportion in which layers are piled on top of one another, in sideways shifts of their layers, or in the position of their atoms in layers to secure maximum potential energy. Particles of clay in suspension are nearly always negatively charged. The process of slip casting depends on the clay's property to absorb ions and remain in fluid suspension. Positive ions added to the slip cause it to coagulate, as the negative ions on the surfaces of the clay particles are balanced by the absorbed positive ions and the particles no longer repel each other. Slip mixing is carried out in powerful machines in order to coat each particle of grog with a film of plastic clay so that it is held in suspension. If the mixture is poured into a plaster of Paris mold, water is absorbed by the plaster and a layer of refractory clay deposited on the surface. When sufficiently thick, the excess slip is poured out, and a hollow pot, the shape of the mold, is obtained. Thin walled crucibles and tubes can be made in this way; solid articles are obtained by using slips of lower water content. The plaster extracts very little water from the slip, which soon sets, owing to loss by evaporation. This process has been recently applied to the making of large blocks (weighing even a ton) for glass tank furnaces; an improved product is obtained. More intimate mixing of the clay and the nonplastic particles results than by customary methods. Large pots for melting glass, formerly built by hand and requiring several months for preparation of the clay mixtures and 5 or 6 weeks more for building a batch of 20 pots, may now be made from a clay mixture prepared in a few hours in a blunging machine and converted to a plastic paste by adding a small proportion of aluminum sulfate. This supplies positive ions to neutralize the negative hydroxyl ions absorbed on the surface of the clay particles. The clay mixture prepared in this way is more plastic than that which is 3 months old. Experiments are being carried out on the slip casting of these large pots. The new method permits greater production in less time, a closer texture more resistant to corrosion, and the utilization of mixtures not plastic enough to be molded by hand. The manufacture of refractory materials is presented in detail. The structure of a fired refractory material is minutely considered with the help of graphs and tabulations. P. concludes that clay refractories and all refractory materials bonded with clay consist essentially of crystals held together by a glassy cement. The properties of a given refractory depend on the nature, size, and shape of the crystals as well as the amount and character of the glassy material. Control of this glassy material in character and proportion determines the extent to which a given refractory can withstand the severest conditions of service. Advances made in the testing of refractory materials are discussed. Formerly, only two tests were called for: chemical analysis and the determination of the melting point (Seger cone test). Results of these tests have repeatedly shown that they bear little or no relation to the behavior of the material under service conditions.

Progressive makers and users of refractories now use tests which simulate as closely as possible the service conditions. Causes of failure are better understood, improvements can be effected, and entirely new products have originated from the new knowledge acquired. P. describes the refractoriness and underload tests with the help of graphs and tables. According to their behavior in the underload test, firebrick are separated into four classes; details are given. Spalling tests show the ability of brick to stand up under severe changes of temperature without cracking. Unfortunately, there is no single, generally recognized test to determine this ability in brick. Both American tests are described, the one formerly standardized and the new and much better one developed by the Mellon Institute. Nothing so elaborate is undertaken in Great Britain, nor are standard spalling tests applied there. Refractories must also be tested for corrosion and erosion by molten slags and glass, a main cause of deterioration and failure affecting both the rate of production and the quality of the product. The five main laboratory methods of estimating resistance to corrosion are reviewed. In both America and Germany, model tank furnaces have been built to test the resistance of refractory blocks to molten glass. Highly corroded structures are illustrated. X-ray pictures of brick before and after testing are shown. Almost a year is required to prepare fire-clay pots for resistance to molten glass, but their working life is only six weeks or less. The procedure in making and testing such pots is given. P. points out technical faults in the chrome magnesite brick now used extensively. Nonplastic materials without the addition of permanent bonding agents are of recent development. They may be molded under pressure or cast from fluid slips, or the molten material may be cast at once into the finished shape. These processes are described in technical detail and illustrated. Enormous difficulties must be overcome in casting directly from molten material at temperatures approaching 2000°C. P. gives experimental work in such castings since 1920. 32 references. K.R.

Refractory mortars. J. Robitschek. *Erde & Stein*, **5** [11] 161–63 (1937).—Refractory mortars formerly consisted of grog and clay. They formed a weak link in the arch. They now consist of a nonplastic material and a hydraulic flux and attain mechanical strength by setting. They are not quite as refractory as the brick, but due to interaction with the brick, they form a monolithic arch of great strength. W.K.

Vibratory molding of metallurgical and coke complex silica brick. I. L. Movshevich. *Vestnik Inzhenerov & Tekh.*, **1938**, No. 2, pp. 122–23.—G. V. Kukolev and A. T. Zelenskaya studied the effect of vibration of great frequency on the molding of high-quality refractories. The vibratory method makes it possible to (1) mold the metallurgical silica brick of rough grain and of normal granulometry and coke complex fashionable silica brick; (2) obtain silica brick of high-quality condensation and mechanical properties at usual and high temperatures; and (3) mechanize the molding process of brick which can not be molded by other mechanical presses and raise labor efficiency 2 to 2.5 times. Properties of silica brick molded by the vibratory method are given. B.E.K.

PATENTS

Burning of magnesia. A. Kummerling. Brit. 501,477, March 15, 1939 (Feb. 19, 1937).

Converter bottoms. August Thyssen-Hütte A.-G. (Paul E. Hardt, inventor). Ger. 668,195, Nov. 28, 1938; 18*b*. 19; *Chem. Abs.*, **33**, 2099 (1939).—In making converter bottoms by heating compositions containing dolomite and tar, channels for the blast are created by securing, in the compositions, thin paper tubes filled with fine dry sand or other material which leaves a residue permeable to gas.

Heat recuperating wall structure for furnaces. L. R. Robinson (United Combustion Corp.). U. S. 2,151,358, March 21, 1939 (July 11, 1936).

Manufacture of basic refractories. Refractory Brick Co. of England, Ltd., and M. Douglas. Brit. 501,755, March 15, 1939 (Sept. 3, 1937).

Manufacture of hearth plates for bakery ovens. Lammerz-Werke, G.m.b.H. Ger. 656,246, Jan. 20, 1938 (July 23, 1936); VI/80*b*. 21.03. Addition to Ger. 655,558.—Asbestos fibers are added to the mixture described in Ger. 655,558 (see following patent). D.A.B.

Manufacturing hearth plates for bakery ovens in the form of molded artificial slabs. Lammerz-Werke, G.m.b.H. Ger. 655,558, Dec. 30, 1937 (March 9, 1936); VI/80*b*. 1.08.—A binding agent such as cement is mixed with proportionately small grains of pulverized tufa; just enough liquid is added to prevent the depositing of moist binding agent on the upper surfaces of the plates or slabs, into which the mixture is molded, thus avoiding the clogging of the pores of the tufa. D.A.B.

Producing fireproof brick from sintered dolomite. Soc. des Hauts-Fourneaux de la Chiers. Ger. 670,193, Dec. 22, 1938 (Nov. 30, 1934); VI/80*b*. 8.02.—The sintered dolomite is pulverized after it is mixed with a small amount of ordinary sinter or binding agent such as blast-furnace dust, slag, or clay; the mixture is pulverized to the extent that it goes through a sieve of 5000 to 15,000 mesh/sq. cm. The mixture is subjected to high pressures of 500 to 2500 kg./sq. cm. in the absence of any liquid and is then cast and fired. D.A.B.

Refractory article. F. W. Higgins (Carborundum Co.). U. S. 2,154,271, April 11, 1939 (March 2, 1937).—A refractory article contains a carbon-comprising constituent bonded with a ceramic bond comprising an oxidic compound of copper, the oxidic compound of copper being substantially uniformly distributed throughout the body of the refractory article.

Refractory compositions. Louis Veaux and Pierre Imbert. Fr. 829,947, July 11, 1938; *Chem. Abs.*, **33**, 1902 (1939).—Dolomite, magnesite, etc., is heated to about 1500° with a small proportion of a flux, *e.g.*, Al_2O_3, SiO_2, or Fe_2O_3. The products are particularly suitable for lining furnaces for making steel.

Refractory and method of making. R. C. Benner and H. N. Baumann, Jr. (Carborundum Co.). U. S. 2,154,318, April 11, 1939 (Dec. 19, 1935).—The process of making fused cast refractories comprises incorporating in a bath of molten alumina a mineralizer composed of a halide of an alkaline-earth metal in an amount of approximately 1%.

Refractory and method of making. G. J. Easter and Karl Brownell (Carborundum Co.). U. S. 2,154,153, April 11, 1939 (July 21, 1936).—The method of forming refractory castings compromises casting molten refractory material into a mold having a superimposed font separated therefrom by a gate, and, after solidification of a layer of refractory material about the inner walls of the mold, maintaining the material in the interior of the font and gate fluid by means of an electric arc and feeding lumps of solid refractory material through the fluid material into the interior of the casting, thereby accelerating and causing the solidification of the interior of the casting before complete melting of the added lumps.

Rendering high-grade ceramic materials impervious. Reinhold Reichmann and Karl Stuckardt (Siemens-Schuckertwerke A.-G.). Ger. 666,698, Sept. 29, 1938 (April 29, 1937); VI/80*b*. 19.02.—Protective pipes for radiators or heat bodies of high temperatures are rendered insulated against heat by introducing SiO_2 into the ceramic material to a predetermined depth before the firing of the finally cast material. D.A.B.

Terra Cotta

Materials for the manufacture of chemical apparatus. E. Rabald. *Chem. App.*, **26** [4] 49–53; [5] 73–75 (1939).—The exacting requirements for materials used in the chemical industry are discussed and explained, and advantages and disadvantages for given purposes are compared. Metals are used extensively, and ceramic materials

such as earthenware, quartz, porcelain, glass, and enamel are used for HNO_3, HCl, and H_2SO_4; acidproof brick for sulfurous acid and sodium disulfite solutions; quartz, glass, earthenware, and enamel are used for phosphoric acid (but not for hot concentrated acid) and for acetic acid; for NaOH and KOH solutions, ammonium sulfate, and ammonium chloride, earthenware and porcelain can be used. Earthenware, porcelain, and enamel are used for paints, colors, foodstuffs, and organic substances. M.H.

Recording method of determining the water permeability of roofing tile. K. SPINGLER. *Tonind.-Ztg.*, **62** [66] 713–16; [67] 727–29; [68] 740–41; [69] 756–58 (1938).—S. discusses existing tests for the permeability of roofing tile and reports the development of a new method based on electrical resistance measurement. A block of plaster of Paris which contains two electrodes 5 mm. apart is cast onto the back of the tile. The tile is exposed to artificial rain under controlled conditions. As the water penetrates through the tile into the plaster, the resistance decreases from 200 × 10^6 ohms in the dry state to 800 ohms when saturated. The change of resistance is recorded on a chart. Special advantages of the system are as follows: (1) the recording is objective, (2) the dry state is clearly defined, (3) the rate of absorption and the amount of water absorbed are measured at the same time, (4) measurements can be made on very tight tile, (5) the rate of drying can be measured, and (6) the size of the area on which the tile rests can be taken into account. W.K.

Stoneware, an important material in the textile industry. WILLY BEHA. *Sprechsaal*, **71** [40] 491 (1938).—Stoneware is used extensively in the textile industry for conduits, pipes, containers, pumps, etc. M.V.C.

PATENT

Tile roof construction. A. O. MUNSEY. U. S. 2,152,080, March 28, 1939 (Aug. 4, 1937).

Whiteware

Attempts to influence glaze tensions by various fluxes. W. SCHWABE AND Z. SYSKA. *Sprechsaal*, **71** [40] 487–89 (1938).—By means of Steger's tension measurer, samples were studied under different conditions of heating and cooling. The temperature of complete softening (600° to 700°) was considered as the end point, since a complete release from tensions exists. A whiteware body of the following composition was used: 60 clay substance, 35 quartz, and 5% feldspar. The glazes were composed in such a way that their "burning up" temperature would not be over 1100°: $1RO \cdot 0.1R_2O_3 \cdot 1.5RO_2$. The experiments show that, with respect to the degree of tension of separate glazes, it is possible to obtain a series of glaze components beginning with those having the highest tensile strength and ending with those having the highest resistance to pressure: Na_2O, K_2O (in order of decreasing tensile strength); PbO, CaO, FeO, SrO, BaO, SnO_2, ZrO_2, ZnO, B_2O_3, MgO (in order of increasing resistance to pressure). The yellow coloring of lead glazes is not accounted for by the iron content but depends on the dissolving of surplus PbO in the melt. The degree of yellow coloring is proportional to the concentration of free PbO. M.V.C.

Tariff question—classification of a feldspathic mass. MARIO DA SILVA PINTO. *Rev. Chim. Ind.* [Rio de Janeiro], **7**, 434–35 (1938); *Chem. Abs.*, **33**, 1834 (1939).—A product intended for use in the production of artificial teeth has the composition feldspar 67, quartz 24, and kaolin 9%, melting at about 1300°; it is not a natural feldspar but may be a slightly kaolinized graphic pegmatite.

BOOK

Dental Materials. JOHN S. SHELL. C. V. Mosby Co., St. Louis, 1938. 413 pp. Price $4.50. Reviewed in *Metals & Alloys*, **10** [1] MA 63 (1939).—Chapters on the following subjects are included: characteristics of metals, theory of alloys, metallography, low fusing base metals, high fusing base metals, noble metals, gold, mechanical properties of metals, gold alloys used in dentistry, base-metal substitutes for gold in dentistry, heat treatment of dental alloys, chemical and electrochemical reactions of dental alloys, amalgams, dental castings, pyrometry, refractory materials, heating equipment, dental porcelain, dental cements, vulcanized rubber dentures, synthetic plastics, and organic technique materials. S. presents an extensive treatment of the various subjects and brings the information up to date. The photomicrographs are not good in many cases as the same paper is used as that for the printed text. The index and illustrations are excellent.

PATENTS

Ceramic body. A. H. FESSLER AND HANS NAVRATIEL. U. S. 2,154,069, April 11, 1939 (Dec. 26, 1935).—A porcelain body for use as an electrical insulator is formed by firing to vitrification a mixture of raw clay and nonplastic material formed by fusing a ceramic batch consisting of approximately 90 alumina, 4 clay, 3 lithium oxide, and 3% magnesium oxide.

Ceramic body. LOUIS NAVIAS (General Electric Co.). U. S. 2,153,000, April 4, 1939 (Feb. 12, 1936).—An interrupting element for a liquid contact switch consists essentially of fused magnesia and a vitreous bonding material.

Combined lavatory and bath. WILLIAM C. GROENIGER AND ROBERT L. DAVISON (John B. Pierce Foundation). Can. 379,583, Feb. 14, 1939 (Oct. 13, 1936). G.M.H.

Electric insulator. H. P. SLEEMAN (R. Thomas & Sons Co.). U. S. 2,154,387, April 11, 1939 (May 24, 1938).—An electric insulator comprises a porcelain body having an area coated with a metallic oxide and a silicate glaze over the coated area, the layer and the glaze being affixed to the porcelain body by firing.

Insulator. C. F. MOLZEN (De Jur-Amsco Corp.). U. S. 2,151,931, March 28, 1939 (Jan. 7, 1937).

Insulator for spark plugs. T. G. MCDOUGAL, A. H. FESSLER, AND KARL SCHWARTZWALDER (General Motors Corp.). U. S. 2,152,656, April 4, 1939 (March 31, 1937).—A spark-plug insulator is made by recrystallizing into a dense nonporous structure aluminum oxide together with 0.5% or more of an inorganic compound of the group comprising manganese oxide, nickel oxide, and cobalt oxide.

Saucer for supporting cups, glasses, and other drinking vessels. ALAN CARRUTHERS. U. S. 2,151,023, March 21, 1939 (Feb. 14, 1938).

Spark plug. GEORGE M. BROWNING. Can. 379,828, Feb. 28, 1939 (Sept. 24, 1937). G.M.H.

Spark-plug insulator. T. G. MCDOUGAL, A. H. FESSLER, AND H. B. BARLETT (General Motors Corp.). U. S. 2,152,655, April 4, 1939 (Nov. 16, 1935).—A spark-plug insulator is made of recrystallized corundum and cerium oxide.

Equipment and Apparatus

Ascertaining and defining fineness of powder. ICHIRÔ IITAKA AND RIUZÔ SHIOTA. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **34**, 897–904 (1938) (in English).—The product of the number of meshes per unit length in a sieve (m) and the distance between wires (d) is a constant which varies with the thickness of the wire used. For a series of standard Tyler sieves the product md = 14.70 mm. (0.579 in.). It is proposed that powder size

be rated by comparison of photographs of the particles at 100 diameters magnification with a set of black and white checkerboard drawings. This system permits classification of sizes corresponding to a 1000-mesh sieve which can not now be manufactured. J.B.A.

Blast-furnace instrumentation. F. N. Hays and J. P. Mikaloff. *Instruments*, **11** [12] 297–300 (1938).—The applications and types of measuring and control instruments in a modern blast furnace are described. F.P.P.

Blasting galvanometer. P. C. Ziemke. *Excavating Engr.*, **33**, 142–43 (1939).—The galvanometer is used to tell whether the blasting circuit is open or closed and whether the correct resistance is present. It may also be employed to test caps as individuals or in groups. A special silver chloride dry cell in it gives a current which is not strong enough to fire a cap; it also gives practically constant voltage until exhausted. W.D.F.

Construction of laboratory electric furnaces and available materials. L. Walden. *Jour. Sci. Instruments*, **16** [1] 1–9 (1939).—W. describes and illustrates methods of winding electric tube furnaces and lists approximate temperature color ranges. Silicon carbide and carbon heating elements, their characteristics, and methods of installation are considered. The composition, specific resistance, temperature coefficient of resistance, working temperature, melting point, source, and special characteristics are listed for heating elements of Ferry, Dullray, Glowray, Brightray, Kanthal, platinum, rhodium, molybdenum, tungsten, Silit, and Globar. Composition, specific resistance, thermal conductivity, coefficient of expansion, normal or maximum operating temperature, softening or melting point, source, and special characteristics are listed for refractories of alumina in various grades, Alundum, Alfrax, Crystalon, Triangle C. C. brand, Carbofrax, mullite, Triangle V. brand, Vitreosil, Pythagras, Triangle W. brand fire clay, steatite, zirconium oxide, and zirconium mixtures. Alundum, Alfrax, and Carborundum cements are listed with respect to maturing temperature, source, and special characteristics. The heat insulating materials Newparex, Nonpareil, diatomaceous brick, alumina powder, asbestos and magnesia mixture, fused magnesia powder, kieselguhr, Sil-O-Cel, rock asbestos, slag wool, silicate cotton, and glass silk are similarly listed. J.L.G.

Criteria for the selection of glasses for eye protection in autogenous welding. M. Prever. *Ind. Meccan.*, **21** [2] 91–95 (1939).—Causes for eyesight troubles developing in welders are explained, and the properties necessary for safe eyeglasses are discussed. Goggles should have glasses which absorb completely the luminous radiation of less than 4800 Å wave length and above 6600 Å, *i.e.*, all red, blue, and violet glasses are unsuitable. The glasses must be sufficiently colored to take away all glare and excessive intensity of the light so that the eye is not subject to harmful strains. The surfaces must be perfectly plane and parallel so that the worker has an undistorted view of the weld. M.H.

Design or adaptation of storage bunkers to prevent size segregation of solids. H. M. Peacock. *Jour. Inst. Fuel*, **11** [57] 230–39 (1938).—A scientifically designed baffle system for compartment bunkers which prevents segregation of particle size is illustrated and described. H.E.S.

Direct observation of the structural changes at high temperatures by use of an electron microscope. Wilhelm Gerard Burgers. *Z. Metallkunde*, **29** [8] 250–51 (1937).—The crystalline structure of a glowing metal surface can be pictured by use of the thermal electron emission of the metal. The electron rays are focused upon a fluorescent shield in a special cathode-ray tube by means of electrical or magnetic fields. By this method, an electron picture can be made which duplicates etch figures. This method is particularly useful in observing conversions or recrystallizations of metals. The conversion of the α phase to the γ phase of iron at 900°C can be shown. C.H.R.

Effect of impact on reinforced concrete beams. T. D. Mylrea. *Can. Engr.*, **76** [1] 9 (1939).—Tests were conducted to determine the reliability of the Izod tension impact test when applied to structural steels used as reinforcement. There is no apparent relation between the strength of a test specimen and that of the same steel when used as concrete reinforcement. No noticeable difference in impact resistance was displayed by any of the several grades of steel used in the beams. B.L.

Electron microscope for studying thermal and secondary electron emission. E. Meschter. *Rev. Sci. Instruments*, **9** [1] 12–15 (1938).—M. describes the construction of a magnetic electron microscope for the observation of self-emitted and secondary electrons from the same surface. Primary and secondary images obtained are illustrated. H.E.S.

Experiments on the amplification of thermocouple electromotive forces. R. Gunn. *Rev. Sci. Instruments*, **9** [9] 267–69 (1938).—G. describes a successful system of amplification employing vacuum-tube amplifiers and commutators for inverting and synchronously rectifying the resulting amplified alternating potentials. Thermocouple electromotive forces less than 10^{-9} volt are readily indicated on a portable microammeter. The over-all useful amplification with portable equipment exceeds 50,000. H.E.S.

Flow indicator for water-cooling systems. W. M. Cady. *Rev. Sci. Instruments*, **9** [7] 229 (1938).—A flow indicator made of glass for estimating the rate of flow of water in water-cooling systems is described and illustrated. The results are accurate to within 5%. H.E.S.

High-temperature vacuum furnace for spectroscopic work. K. R. More. *Rev. Sci. Instruments*, **9** [6] 199–200 (1938).—A high-temperature vacuum furnace suitable for spectroscopic investigations is described. A coil of tungsten wire is used as the heating element. Thermal insulation is provided by the use of insulating brick. Temperatures of the order of 2000°C are attained with a power consumption of 2.5 kw. H.E.S.

Instrument for the measurement of anomalous viscosity. C. F. Goodeve. *Jour. Sci. Instruments*, **16** [1] 19–27 (1939).—G. describes a new form of viscometer in which the fluid is placed in a rotating container with a conical inner surface. A viscous drag is imparted to a coaxially suspended or pivoted inner cone, and the torque produced is measured by means of a torsion wire or spring. The rate of shear is altered by a movement of one of the cones relative to the other along the axis, thus altering the separation between the moving surfaces. The instrument is especially designed for the measurement of anomalous viscosities. Very high rates of shear may be obtained without the occurrence of turbulent flow. Speeds of 1.25 r.p.m. to 320 r.p.m. can be used. Viscosities from below those of ordinary liquids and up to 1000 poises may be measured. With a special bearing, much higher viscosities (400,000 poises) can be measured. Three drawings. J.L.G.

Jigging, with special reference to the moving-sieve buddle jig. H. Hardy-Smith. *Proc. Australasian Inst. Mining & Met.*, **105**, 1–52 (1937); *Brit. Chem. & Phys. Abs.-B*, **58** [1] 2 (1939).—The theory and mathematics of the process of jigging are discussed, and a description is given of the moving-sieve buddle jig. The seal between the edge of the circular sieve and the compartment is made by means of a fixed annulus of flexible rubber; the feed is delivered to the center and the drive is of a special type.

Machining of magnesium alloys. E. Rauscher. *Maschinenbau*, **17** [21–22] 561–63; [23–24] 613–15 (1938).—The advantages of magnesium alloys over other materials from the standpoint of machining are as follows: (1) they have a low specific cutting pressure (24 kg./mm.^{2} as compared to 160 kg./mm.^{2} for steel having a tensile strength of σ_B = 50 kg./mm.^{2}); (2) the cutting speed can be very high because of the long life of the cutting tool; and (3) the shavings are easily removed because they break easily. Such alloys can be easily turned, planed, or drilled. In drilling, the following precautions must be observed: (1) drillings must be removed in short fragments, (2) drillings must be removed from the hole as

quickly as possible, and (3) friction in the drill hole should be held at a minimum. R. discusses planing, cutting, sawing, thread-cutting, reaming, filing, grinding, lubrication, and cooling of magnesium alloys. Precautions are necessary to avoid explosions while using any of these methods. Details and illustrations are presented for each method of machining. Illustrated. C.H.R.

Nonelectrical instruments. R. S. CLAY. *Jour. Sci. Instruments*, **16** [2] 47–53 (1939).—C. describes the Lovibond-Schofield colorimeter which uses tinted glasses as comparison media, the Kodak colorimeter which utilizes prisms and a photocell, reflecting microscopes, the Leitz-Jelley refractometer for measuring the index of a drop of liquid, microscopes and objectives, projectors, instruments for control of temperature and humidity, balances, a metallurgical mounting press, dust-particle counting, a glass still, a recording manometer, and lecture and teaching apparatus. Five figures. J.L.G.

Photoelectric current limiting device for insulation measurements. E. B. BAKER AND H. A. BOLTZ. *Rev. Sci. Instruments*, **9** [6] 196–98 (1938). H.E.S.

Preparation in vacuum of clay raw materials by a new process. OTTO MANFRED. *Argile*, No. 186, pp. 17–19 (1938).—In addition to the usual treatment of clay raw materials by grinding, mixing, and soaking in water, dearing in a vacuum further homogenizes them, guarantees a regular distribution of the liquid part in the mass, and minimizes supplementary liquid additions. A process similar to that used in the manufacture of safety glass in which all air and other gases are expelled from the pressure surface before actual pressing begins (H. G. Bodenbender, *Matières artificielles*, **25**, 192 (1935)) is particularly recommended in the preparation of clays where a recent study of colloids has shown that the air stored by absorption of exterior surfaces or that mechanically confined diminishes, principally at the exterior surface of the material, the exchanges of energy produced there (R. H. Holm and B. Kirschstein, *Usines Siemens*, **15**, 122 (1935)). M.V.C.

Properties of some free-machining lead-bearing steels. J. H. NEAD, C. E. SIMS, AND O. E. HARDER. *Metals & Alloys*, **10** [3] 68–73 (1939).—Machinability and other mechanical property test data on a variety of open-hearth and some Bessemer plain carbon and alloy steels are reported. The addition of Pb to steel results in considerable improvement in machinability of the steels tested to date, with remarkably little effect on tensile strength, hardness, impact strength, and endurance limit. About 0.25% Pb seems to be the best amount; the Pb is evidently present as uniformly dispersed submicroscopic particles rather than in solid solution. F.P.P.

Rapid and accurate measurement of line positions on X-ray diffraction films with the aid of a cathode-ray oscillograph. H. TATEL AND R. HULTGREN. *Rev. Sci. Instruments*, **9** [2] 47–50 (1938).—An apparatus containing a cathode-ray oscillograph has been developed for the measurement of positions of X-ray diffraction lines. A small portion of the film is scanned by a moving slit. A trace of film transmission *vs.* distance appears on the screen of the oscillograph. Lines are easily measured by centering their traces on the screen. Ordinary back-reflection X-ray lines can be measured to better than 0.02 mm.; sharper lines or points may be located much more accurately. H.E.S.

Recent developments in industrial instruments for the measurement and control of gas temperatures. C. DUPEN. *Jour. Inst. Fuel*, **12** [61] 40–46 (1938).—A description of the Pyromaster is presented. It is essentially a potentiometer pyrometer and uses the well-known potentiometric principle of measuring thermocouple electromotive force. It differs from the more conventional potentiometer in that there are no moving parts in the balancing mechanism except when a change in temperature takes place. It has been successfully applied as a controller operating either electric or pneumatic control valves and devices. Many applications are illustrated. H.E.S.

Simple magnetic apparatus for phase transformation studies of ferrous alloys. R. BUEHL AND J. WULFF. *Rev. Sci. Instruments*, **9** [7] 224–28 (1938).—A simple apparatus is described for the determination of phases and the investigation of sluggish phase transformations in ferromagnetic alloys by means of magnetic measurements made at elevated temperatures. The force exerted on a small sample is measured when it is suspended in a furnace held between the poles of an electromagnet which produce a magnetic field of uniform gradient. A few measurements on stainless steel are included. H.E.S.

Small clay-winning machinery. F. RIEDIG. *Tonind.-Ztg.*, **63** [5] 47–51 (1939).—R. describes clay-winning and hauling machinery suitable for small plants. Capacities and dimensions of the products of the principal manufacturers are given. Six tables. Illustrated. W.K.

Supermicroscope. B. v. BORRIES, H. RUSKA, AND E. RUSKA. *Chem.-Ztg.*, **62**, 561–65 (1938); *Metals & Alloys*, **10** [2] MA 110 (1939).—The supermicroscope allows a magnification of 30,000 as compared with 2000 maximum of an optical microscope. The definition is so good that it allows an additional optical magnification up to 4 or 5 times. The total magnification amounts to about 100,000. The principle of the invention is to work with rays whose wave lengths are much smaller than those of light rays, *i.e.*, cathode rays. The "lens system" consists of coils enclosed in cases shaped like pole shoes, giving very small focal lengths. The rays become visible by change in wave length which is effected by means of a fluorescing screen. The cathode rays can also be used for exposing photographic film. It is necessary to enclose the object to be investigated, the screen, and the light-sensitive plate in the vacuum. It takes only 1 min. to lock the object into the vacuum and 2 min. to lock the plate. Another distinction of the new device is that it shows the distribution of masses, whereas the optical microscope shows the distribution of colors and refractive index. Major fields of application have been in medical and biological research, although the supermicroscope has been used for investigation of dyes, ores, and other pulverulent materials.

Temperature-sensitive magnetic alloys and their uses. L. R. JACKSON AND H. W. RUSSELL. *Instruments*, **11** [11] 280–82 (1938).—The development of a series of alloys whose variations in magnetic permeability with temperature can be utilized as the basis for temperature control devices is described. Such alloys, to be useful as components of temperature-sensitive contactors, reactors, and transformers, must (1) not be unduly sensitive to slight variations in composition, (2) have Curie points that are the same whatever the heat treatment and for rising or falling temperatures, (3) be capable of being formed into sheets or other shapes by rolling or forging, and (4) have as high a permeability as possible at temperatures below the Curie point. The quaternary Fe–Ni–Cr–Si system most completely satisfies these requirements. The alloys for which data are plotted in the paper contained a constant Si percentage of 0.30%, Cr contents varying from 0 to 20%, and Ni contents from 35 to 95%. Curie point and magnetization values are plotted against composition, and the magnetism-temperature curve and room temperature magnetization curves of typical alloys in the series are shown. F.P.P.

Thyratron-controlled thermostat. J. M. STURTEVANT. *Rev. Sci. Instruments*, **9** [9] 276–79 (1938).—A thermoregulator employing a resistance thermometer and phase shifting thyratron circuit is illustrated and described. Continuous control precise to within ±0.003° has been obtained in a water bath of average quality and design. H.E.S.

Vacuum furnace for the production of single crystals of metals and alloys. F. C. NIX. *Rev. Sci. Instruments*, **9** [12] 426–27 (1938).—A molybdenum wound vacuum furnace for melting single crystals of pure metals is described and illustrated. H.E.S.

What instruments do for the ceramic industries. F. H. NORTON. *Instruments*, **12** [1] 7–8 (1939).—Instrumentation in the ceramic industries is the backbone of improved processes that have resulted in superior quality of ware and

reduction in manufacturing cost. Refractories, heavy clay products, plant standardization, and applications of instruments in the pottery are discussed. Further improvement is required in instruments for high-temperature recording and controlling equipment to assure the accuracy and ruggedness now found in the lower temperature instruments. Thermocouples and refractory protection tubes capable of being used at temperatures up to 3200°F and a simplification of the recording optical pyrometer that will allow it to be more generally used in the ceramic industry are needed. F.P.P.

SEPARATE PUBLICATION

Westinghouse stokers. *Westinghouse Electric & Mfg. Co. Booklet*, No. B.2170, 18 pp.—Single and multiple retort stokers, designed to meet every bituminous coal burning requirement in industry, are described. These include (1) the following multiple retort stokers for boilers from 300 rated boiler horsepower up: (*a*) continuous ash discharge stokers with link-grate action, (*b*) clinker grinder stokers with link-grate action, (*c*) dump grate stokers with agitator, (*d*) dump grate stokers; and (2) single retort stokers for boilers from 100 to 500 rated boiler horsepower, in moving or stationary grate types. Copies of the booklet may be obtained from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PATENTS

Apparatus for measuring temperature. H. G. Mead (Leeds & Northrup Co.). U. S. 2,151,928, March 28, 1939 (July 31, 1935).—In an apparatus for measuring the temperature of a refractory wall structure, a refractory block for inclusion as a portion of the wall structure provided with a target permanently an integral section of the block and having external and internal recesses defining the target section and through which the section is visible from the exterior and exposed to the interior of the furnace, respectively, the thermal conductivity of the refractory of the block being substantially higher than the thermal conductivity of the refractory of the wall structure.

Apparatus for transferring molten materials. J. D. Pugh (A. A. Pugh). U. S. 2,151,391, March 21, 1939 (May 29, 1936).

Apparatus for transportation of molten materials. J. D. Pugh (A. A. Pugh). U. S. 2,151,392, March 21, 1939 (June 5, 1936). S. W. Randolph (Koppers Co.). U. S. 2,151,393, March 21, 1939 (July 1, 1936).

Ceramic drill. R. A. Hawn. U. S. 2,151,205, March 21, 1939 (May 28, 1936).

Device for cutting off clay tubes or pipes by use of a clay wire cutter. Josef Heckenberger. Ger. 669,532, Dec. 8, 1938 (Nov. 30, 1936); VI/80*a*. 42. D.A.B.

Dust-collecting plant. Hermannus van Tongeren (Buell Combustion Co., Ltd.). Can. 379,744, Feb. 28, 1939 (Dec. 23, 1937). G.M.H.

Gas-cleaning apparatus. John P. Irwin, Charles B. Thorne, and Merrill Cox (International Precipitation Co.). Can. 379,776, Feb. 28, 1939 (Aug. 21, 1935). G.M.H.

Method and apparatus for molding materials. B. A. Jeffery (Champion Spark Plug Co.). U. S. 2,152,738, April 4, 1939 (April 17, 1936).—The method of compressing granular or powdery material comprises filling the material into an elongated cavity open at one end and otherwise surrounded by self-sustaining deformable material, closing the open end, and compressing the powder into a self-sustaining body by applying to the deformable material a compressing force high in proportion to the resistance of the deformable material to deformation and thereby forcing the deformable material to flow against the material within the cavity.

Photoelectric color measuring and analyzing apparatus. A. L. Holven and T. R. Gillett. U. S. 2,152,645, April 4, 1939 (Dec. 19, 1934).

Process and apparatus for spray drying. P. T. Zizinia and T. L. McKenna (Spray Dryer Laboratory Corp.). U. S. 2,154,000, April 11, 1939 (Sept. 7, 1935).

Roller crusher. Georges A. Biloco (Fonderie de Plessisville Compagnie, Ltée.). Can. 379,567, Feb. 14, 1939 (May 27, 1937). G.M.H.

Screening apparatus. Thomas A. Dillon. Can. 380,121, March 14, 1939 (April 28, 1937). G.M.H.

Sintering apparatus. Richard C. Yates (Canadian Furnace, Ltd.). Can. 380,012, March 14, 1939 (Oct. 1, 1937). G.M.H.

Solid-pulverizing apparatus. Elman B. Myers. Can. 380,100, March 14, 1939 (Oct. 25, 1937; in U. S., Nov. 5, 1936). G.M.H.

Spray gun. George McKnight. U. S. 2,152,767, April 4, 1939 (Sept. 8, 1936).

Thermocouple. R. R. Ridgway (Norton Co.). U. S. 2,152,153, March 28, 1939 (Nov. 22, 1935).

Tile-making machine. Henry Jansen (Janline Tile Co., Inc.). U. S. 2,153,307, April 4, 1939 (April 1, 1937).

Kilns, Furnaces, Fuels, and Combustion

Combustion of fuel on a traveling grate. E. S. Grumell and A. C. Dunningham. *Jour. Inst. Fuel*, **12** [62] 87–95 (1938).—A survey of the phenomena attending the combustion of coal on a traveling grate is given. The following factors are discussed: (1) three zones of a fuel bed (ignition, combustion, and burning-off zones); (2) physical character of the fuel bed; (3) effect of primary air rate; (4) swelling properties of coal; (5) fuel-bed resistance; (6) grate temperatures; and (7) initial ignition of fuel bed. See "Ignition—," *Ceram. Abs.*, **18** [3] 82 (1939). H.E.S.

Comparison of carbon and graphite electrodes in electric arc furnaces. H. Weitzer. *Stahl & Eisen*, **58**, 542–46 (1938).—After referring to the history and manufacture of graphite and carbon electrodes for electric arc furnaces for steelmaking, W. describes experiments with three furnaces of 6 to 7.5 tons capacity in which the relative merits of graphite and carbon electrodes were tested. Graphite electrodes will take nearly three times the load of carbon and last twice as long, but because the cost of graphite is over three times that of carbon (in Germany), it is expensive to use. L.R.B.

Experiments on the continuous hydrogenation of coal. N. Booth and F. A. Williams. *Jour. Inst. Fuel*, **11** [60] 493–503 (1938).—Experiments are described for investigating the effect of certain variables on the hydrogenation of coal in a small-scale liquid phase continuous plant designed to treat 12 kg. of coal per day. The variables whose effects have been studied are hydrogen input, pressure, paste input, and temperature. The catalyst used throughout was stannous hydroxide, equal in amount to 0.1% of the coal. The coal was made into a paste with oil boiling above 250°C derived from the product of previous operations. H.E.S.

Gas-fired decorating kiln. P. Dressler. *Ind. Heating*, **6** [3] 220–26 (1939).—Constructional details are described in full; the very low fuel consumption, 500 cu. ft./hr. of city gas of 525 B.t.u. for an output of 50 trays per 24 hr. containing 1343 lb. of chinaware and 2274 lb. for supports to hold the ware on loading trays of 642 lb., is due to the well-insulated shell, a minimum of dead weight, and maintenance of a perfect air-gas ratio, with no unburned gases in the exhaust. M.H.

Oil firing. O. T. Koritnig. *Emailwaren-Ind.*, **15** [46–47] 303–305 (1938).—K. explains the following factors which are involved in the efficient operation of oil firing: (1) preheating the oil to thin it and facilitate atomizing; (2) atomizing with compressed air which is used in industrial furnaces and which requires careful regulating to obtain either reducing, neutral, or oxidizing flame; (3)

the use of steam for atomizing and the use of oil under pressure, both of which methods are employed in large furnaces; (4) vaporization of oil used in smaller furnaces; (5) operation of burners and atomizers; and (6) cleaning. M.V.C.

Radiographic examination of coal. R. BEECHING. *Jour. Inst. Fuel*, **11** [57] 240–42; **12** [61] 35–39 (1938).—B. describes a method of showing up some of the details of the physical structure of coal by radiographic examination of slices of coal soaked in a solution of lead salts. Useful information is obtained by impregnating the coal with a solution containing heavy atoms which show up readily under X-ray examination. Dull coals are porous to aqueous solutions of lead salts whereas the bright coals are not. Fusain is, in general, much more absorbent than durain. Calculations based upon the measurements of the rate of diffusion of a lead solution show that the mean diameter of the capillaries in the coal is of the order of 50 $\mu\mu$. H.E.S.

Removal of suspended matter from industrial gases. R. R. HARMON. *Jour. Inst. Fuel*, **11** [60] 514–35 (1938).—H. describes the following means of collecting or otherwise removing suspended matter from gases: (1) settling, (2) centrifugal force, (3) impingement, (4) filtration, (5) scrubbing, (6) electrical precipitation, and (7) condensation. The details of the Peabody system of cleaning industrial gases are described. Illustrated. H.E.S.

Smoke-producing tendencies in coals of various ranks. H. J. ROSE. *Heating, Piping & Air Conditioning*, **11** [2] 119–22 (1939).—The methods of investigation are described, and the results are represented graphically. Six charts. J.L.G.

Technical combustion properties of gas generator gas. OSCAR KNAPP. *Glashütte*, **68** [33] 553–56; [34] 579–80 (1938).—Exhaustive studies have recently been made on the technical combustion properties of gases and the varieties of technical gases. These studies have furnished more reliable numerical values which enable engineers to select the most suitable kind of gas and gas composition for a furnace, to adjust the flame correctly, to maintain the proper waste-gas composition, and, by these means, to control the combustion processes in the furnace economically and efficiently. K. gives methods and formulas for calculating the properties of gases, which include volume, weight of a cubic meter of gas in kilograms, specific gravity, steam content, and calorific or heating power which is the most important index of gases. There are two values for the calorific power: (*a*) the upper value, which represents the amount of heat resulting from the complete combustion of a standard cubic meter of gas when the combustion products are cooled to the initial temperature after combustion and the water formed by combustion is in a liquid state; and (*b*) the lower value, which decreases according to the heat of vaporization of the water formed by combustion. This lower value is generally used in making calculations for technical combustions because the water of combustion in technical furnaces is always in the form of steam in the waste gases. The calorific values of the gas mixture and of the generator gas can be additively obtained from the calorific values of the separate gases. The calculation of the quantity of air necessary for combustion of generator gas requires the knowledge of the composition of the gas; to obtain a combustion as complete as possible in practice, the gas is supplied with enough air so that, after combustion, a small quantity of excess oxygen is present. This requires knowledge of the composition of the waste gases. The upper and lower limits of ignition or priming are the concentration limits within which the mixture of gas and air can be ignited. The rate of ignition is especially important in the determination of the combustion properties of a gas. The greater the rate of ignition, the greater is the volume of gas and air that can be fed through a given burner in a unit of time. Two methods used for determining the ignition rate are given. By changing the rate of ignition, different thermal effects can be achieved; if a uniform distribution of heat over a large space is desired, a gas or gas mixture with a lower ignition rate and a smaller addition of primary air are used. This gives a large cone and flame length. If a hot fire is to be concentrated in a small space, a gas with high ignition rate is used, which gives a shorter flame and a lower cone. Hydrogen has a high ignition rate; carbon monoxide and methane have a low rate. All gases have their highest ignition rate with an excess of gas. The ignition rate of gas mixtures can not be calculated from the values of the component gases because combustion reactions are conditioned by the composition of the gas mixture. The highest ignition rate for generator gas lies between 30 and 35 cm./sec. The specific flame power or efficiency of a fuel gas is the heating power which the flame produces at a definite cone height and in dependence on the fuel gas-air mixture in a standard burner of 1 sq. cm. cross section. Two kinds of specific flame power are distinguished: (*a*) primary, which results from the primary combustion in the flame cone; and (*b*) secondary, which results from the secondary combustion of the excess fuel gas with the secondary air. The sum of these two gives the total specific flame yield. Flame temperature without dissociation in °C, flame temperature with dissociation of the combustion products, and the composition and volume of waste gases were also calculated. A table gives the numerical values of the properties of CO_2, CO, H_2, CH_4, and N_2. M.V.C.

Geology

Calcination conditions for limestone, dolomite, and magnesite. JOHN E. CONLEY. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1037; *Mining Tech.*, **3** [2] 15 pp. (1939).—Cylindrical specimens were generally used. They were put in a vertical tube in an electrical furnace already heated to the desired temperature. A thermocouple was inside each specimen. The heating was done in an atmosphere of carbon dioxide at 1 atm. pressure. On a sample of high-calcium limestone the temperature rose rapidly to 930°C and was then nearly constant, later rising slowly to just over 1000°C as the last of the carbon dioxide was evolved. Dolomite shows a break in its heating curve at 725°C, where it dissociates to magnesite and calcite. The carbon dioxide from the magnesite then comes off, and only after heating to a higher temperature does the carbon dioxide in the calcite evolve. Magnesite shows a break in its heating curve at about 620°C. Examination of partially calcined specimens shows that the calcination proceeds at slightly different rates in different directions in the stone. A linear equation is derived which may be used to represent the rate of calcination of the limestone. W.D.F.

Classification of hydrated aluminum silicates from the viewpoint of a petrographer and a geologist. P. URBAIN. *Compt. Rend. Soc. Géol. France*, **1936**, 147–49.—U. gives a short résumé of the properties of different clay minerals. N.M.S.

Clay and fuller's earth. F. SCHWARZ. *Sprechsaal*, **71** [34] 415–18; [35] 429–31; [36] 439–40 (1938).—Simple tests were made with clays and fuller's earth which permitted their classification with kaolinites and montmorillonites. As a new and complete criterion, curves of buffered neutralization are considered which permit the rapid determination of a series of properties of clay colloids. Neutralization curves show sorption values and functional values depending on them, such as base exchange and plasticity. Water determination in clays usually helps in recognizing clays; this is confirmed by means of acid and base indicators. Decomposition by means of sulfuric acid alone is seldom indicative. The process of stepwise neutralization of clay colloids can be followed up quantitatively. The stepwise neutralization with a known p_H indicates clay colloids as buffer substances. The boiling of clay samples with alkali polysul-

fide, the ultramarine sample, yields conclusions as to refractoriness and weathering. M.V.C.

Crystalline chemistry of lithium ferrite. ALEX HOFFMANN. *Naturwissenschaften*, **26** [26] 431 (1938).—The compound $Li_2O \cdot 5Fe_2O_3$ crystallizes in a spinel-type lattice and is strongly magnetic. The lattice constant is 8.309 Å. The elementary cell consists of $2Li_2Fe_{10}O_{16}$ molecules. C.H.R.

Experiments on the orientation of quartz in deformed rocks. DAVID GRIGGS AND JAMES F. BELL. *Bull. Geol. Soc. Amer.*, **49** [11] 1723–46 (1938).—Theories of the deformation of quartz are reviewed and compared. Experiments were performed by the authors on quartz crystals in an attempt to produce plastic flow. The maximum laboratory pressure available, about 138,000 atm., did not produce a measurable degree of plasticity. Undulatory extinction, however, resulted. Quartz shows a tendency to fracture into needles under high temperatures. A.C.B.

Geological applications of the p_H notion. M. DÉRIBÉRÉ. *Compt. Rend. Soc. Géol. France*, **1938**, 17–19.—D. supplements his research on the effect of variation in p_H on the rate and character of sedimentation of different suspensions (*Mines, Carrières, Grandes, Entreprises*, No. 165, July, 1936; *Ann. Chim. Anal. Chim. Appl.*, **18**, Nos. 10–15 (Oct., 1936)). From the nature of a sediment, the approximate acidity of its environment during deposition is deduced; a clay band with a sandy top is the result of sedimentation in an acid medium, whereas if the sand is at the base the p_H was on the neutral or alkaline side, because a clay suspension is sedimented quickly in an acid medium and is stabilized in an alkaline one, contrary to a silica suspension. D. was able to determine the p_H value of a sediment during its formation by observing the separation of its suspension in different vessels filled with water of known p_H value. He worked first on the range p_H 4 to 9, with one unit difference between each, then with a set of liquids with 0.2 difference in the interesting (critical) zone. N.M.S.

Hydrogen-ion concentration of some bauxites. M. DÉRIBÉRÉ. *Compt. Rend. Soc. Géol. France*, **1938**, 299–300.—Examination of different bauxites on the lines indicated seems to be desirable. The p_H values of the bauxites examined were determined by digesting 10 g. of powder in 100 g. of distilled water and using a Péhavi (Hartmann and Braunn) equipped with antimony electrodes (quinhydrone for some measurements). In bauxite from one locality, the p_H values found varied from 7.2 to 7.96, increasing with the change in color from yellow to rose to red. In another locality, they varied from 6 to 7.6. Owing to the slight influence, if any, of pure alumina on the p_H of water and to the fact that iron hydroxide causes variation only toward the alkaline side (hence the high value of p_H in the more reddish specimens), D. sought the reason of this change in the p_H in the differing clay content which depends on the mode of formation of the deposit; in an alkaline medium the clay is found in the upper part of a layer, and in a nearly neutral medium the clay is sedimented more easily than the hydroxides. The p_H values of different pisolites and of the corresponding ground mass, boehmite and gibbsite (J. de Lapparent and Raymond Hocart, *Ceram. Abs.*, **18** [1] 34 (1939)), were determined. The p_H of the pisolites was constantly found to be higher, corresponding to a higher concentration of iron and also to formation in a more alkaline medium. N.M.S.

Hydrothermal alteration of igneous rocks. GEORGE M. SWARTZ. *Bull. Geol. Soc. Amer.*, **50** [2] 181–238 (1939).—S. discusses the general principles of the chemical, mineralogical, and textural changes involved in hydrothermal alteration. The primary texture is more or less destroyed but seldom completely. Many rocks are converted into a feltlike aggregate of secondary minerals, chiefly sericite, quartz, pyrite, carbonates, chlorite, epidote, alunite, adularia, albite, and various sulfides. Chemical changes are extensive and vary widely. Potash and water are gained, and iron, magnesia, lime, and soda are lost. Silica and alumina remain almost constant. Mineral alternations include silicification, sericitization, biotitization, propylitization, serpentization, uralitization, carbonation, pyritization, albitization, alunitization, kaolinization, and a few other changes. A.C.B.

Ignition at low temperatures of organic matter in soils. J. S. HOSKING. *Jour. Agr. Sci.*, **28** [3] 393–400 (1938).—Low-temperature ignition (100° to 500°C) of soil organic matter is investigated. Appreciable losses are found below 100°; up to 200° heating results essentially in distillation of volatile constituents; between 200° and 300° destructive distillation is the major reaction. These reactions are responsible for the removal of about 85% of soil organic matter. At 300° the greater part of the residual organic matter consists of carbonaceous material. The final reaction is simple ignition of this residual. Heating for 2 hr. at 450° or ½ hr. at 500° is recommended for the removal of 99% of soil organic matter. Three figures. P.S.D.

Italian national raw materials used in the ceramic industry. FILIPPO CAVACECE. *Corriere Ceram.*, **19** [9] 283–99 (1938).—For many centuries the kaolin pits of Tretto, near Schio, have been famous for their white porcelain clay known in industry as "Clay of Vicenza." C. gives a full description of the geological origin, location, and exploitation of the deposits. The chemical composition, characteristics, and applications of the clay are also discussed in detail. M.V.C.

Kyanite. ANON. *Mineral Ind.*, **46**, 671 (1937).—During 1937, kyanite was mined commercially in North Carolina, Georgia, Virginia, and California. About 7670 short tons were imported from India during 1937. B.C.R.

Microscopic textures of argillaceous rocks. P. URBAIN. *Bull. Soc. Géol. France*, **7**, 341–46 (1937).—In many cases the origin of the argillaceous sediments was determined from their textural analyses. The following textures are described: oriented, reticulate, curly, and cyclic structures. Stress is laid on the effect of electrolytes on the sedimentation of such rocks. The major part of kaolinite in a NaCl solution (with a concentration similar to that of the sea, 28 to 30/1000) is deposited in a relatively short time; after this, the solution stays indefinitely turbid (determined by measuring its transparency). In nature, the first violent coagulation, *e.g.*, of river sediments entering a sea, will result in a primary-coagulation sediment composed of floccules consisting of a large number of mineral particles. The remaining particles in suspension, when deposited (away from shores), will form late argillaceous deposits, the particles of which are independent or are formed only as floccules of relatively small size. This last character is not confined to the late argillaceous deposits but is also observed in fresh-water deposits where the p_H is unchanged and low. N.M.S.

Origin of bentonites from North Africa. J. DE LAPPARENT. *Compt. Rend. Soc. Géol. France*, **1937**, 126–28.—L. proves that the bentonite (montmorillonite with or without kaolinite) previously held to be directly or indirectly derived from andesitic material is formed from (vitreous) rhyolites. He does not exclude the possibility that it may be derived from vitreous andesites. The formation of montmorillonite from such an acid rock (rhyolite) could be understood from the fact that the montmorillonite is due to replacement; the devitrification of the rhyolitic vitreous debris took place in a hydromagnesian medium (pneumatolysis). N.M.S.

Petrographic study of the principal plastic terms of the Liasso-Jurassic series of Calvados. P. URBAIN. *Compt. Rend. Soc. Géol. France*, **1937**, 24–26.—U. identified his clay minerals, using X-ray, thermal analysis, and electrical methods together with the classical petrographic methods (chemical analysis, microscopic examination, and mechanical separation). Halloysite dominated. Other clay minerals in different horizons are beidellite, kaolinite, and montmorillonite. The stability of suspensions of the sediments studied varies directly with the alkali and inversely with the $CaSO_4$ content. The latter, together with the carbonate, was eliminated by electrodialysis. The alkalinity of the suspensions (in water) is of the same order as that of the present sea ($p_H = 8.0 \pm 0.6$). N.M.S.

Relation between moisture content and flow-point pressure of plastic clay. RAY T. STULL AND PAUL V. JOHNSON. *Jour. Research Nat. Bur. Standards*, **22** [3] 329–37 (1939); R. P. 1186. Price 5¢.—The relation between moisture content and flow-point pressure of a Maryland clay, a Georgia kaolin, and a Kentucky ball clay was studied. Their moisture contents ranged from 17 to 34, 24 to 40, and 26 to 52%, respectively, and the flow-point pressures ranged from 8 to 400 lb./in.². The clays were extruded from a knife-edged die by means of a cylinder and a mechanically driven piston. The flow-point pressures were determined on the average of 18 load readings for each test, and the percentages of moisture were determined on a composite sample of 18 portions of the clay column. Tests were made with two extrusion cylinders of different sizes and three dies of different diameters to determine the effect of different cylinder and die sizes upon the flow-point load. The following conclusions were drawn: (1) The flow-point load decreases with decrease in diameter of the extrusion cylinder, with increase in diameter of the die, and with decrease in distance of the piston head from the die. (2) The plot of the flow-point load against corresponding distance of the piston head from the die when the load reading is observed produces a curve similar to a sine wave with reference to a sloping axis. (3) The relation between flow-point pressure and percentage of moisture content of the clays can be expressed by the equation $(p + b)(w - a)^m = K$, where p = flow-point pressure in lb./in.² of the piston head, w = moisture content of the clay in percentage of the dry weight of the clay, and a, b, c, and K = constants. The values of a, m, and K are constant for a definite clay but different for different clays, while asymptote b is substantially constant for all three clays. The asymptote a represents the percentage of uniformly distributed moisture in the clay before it becomes amenable to flow at theoretically infinite pressure. (4) When $p = 0$, $w = \left(\frac{K}{b}\right)^{1/m} + a$, where w represents the percentage of moisture of the clay at the transition point where, theoretically, the slightest pressure would cause flow. (5) The soft-mud consistency of the clays was obtained at a flow-point pressure of about 20 lb./in.², and the stiff-mud consistency was obtained at approximately 80 lb./in.². A difference in moisture content of 1% for the soft-mud consistency caused a difference of approximately 4 lb./in.² in flow-point pressure, and a like difference in moisture for the stiff-mud consistency caused a difference of approximately 22 lb./in.² in flow-point pressure. R.A.H.

Relation of composition to properties of clays. RALPH E. GRIM. *Jour. Amer. Ceram. Soc.*, **22** [5] 141–51 (1939).

Revivification characteristics of bauxite used in percolation filtration. R. H. HUBBELL, JR., AND R. P. FERGUSON. *Refiner & Natural Gasoline Mfr.*, **17** [11] 541–45 (1938).—Investigation of the effect of continued revivification on the adsorptive qualities of bauxite reveals that the revivification characteristics of this material vary with the type and source of stock handled and the method of filtration as follows: (*a*) In the solution percolation of residual stocks, bauxite retains throughout its life an efficiency of approximately 85% of its initial value. (*b*) In the straight percolation of bright stocks, average values in the vicinity of 80% of new material are obtained. (*c*) The bauxite filtration of distillate stocks requires the maintenance of low temperatures of revivification. (*d*) Bauxite manifests a great advantage over other adsorbents in the percolation of petrolatums and related stocks, owing to the high yields and the tasteless and odorless character of the products. (*e*) Fresh bauxite exerts a solvent action greater than that of fuller's earth, a characteristic which diminishes with repeated reburning. Numerous curves and tables of test data are given. J.J.H.

Rutile in the Dogger. R. H. RASTALL. *Geol. Mag.*, **76**, 109–15 (1939).—This rutile has always been derived from older rocks, as it is worn and battered in nearly all cases. Crystal faces are poorly preserved. Colors show a very wide range. The most common colors are yellow and orange, grading through darker colors to crimson and brown and through lighter colors to a few crystals that are nearly colorless. Other colors range from yellowish brown to olive brown. Pleochroism is usually confined to variations in intensity of the same color, but in the olive and greenish varieties, in extreme instances, it may be ω = green and ϵ = purple. Polysynthetic twinning is nearly always present. Chordate twinning is common. The source of this rutile has not been determined. W.D.F.

Significance of specific gravity of clays with respect to their mineralogical composition. ANTTI SALMINEN. *Suomen Kemistilehti*, **10**, 3–7 (1937); abstracted in *Chem. Zentr.*, **1939, I**, 61.—S. determined the specific gravity and humus and water content of some Finnish clays. When the values obtained are corrected or adjusted to the humus and hygroscopic water contents, the densities obtained compare well with those of other clays and lie between ~ 2700 and 2731. This density indicates that these clays contain mostly mica (about 50%) and are difficult to decompose. M.V.C.

Stereochemistry of silicate minerals. H. STRUNZ. *Z. Ges. Naturw.*, **4**, 181–89 (1938); *Chem. Abs.*, **33**, 2032 (1939).—The cations of the silicates are classified into three groups: (1) those with high coördination activity (coördination number 4), Si, Ge, P, As, Be, B, Al, and exceptionally Ti, Fe, Zn, Mg, and Mn; (2) those with a medium coördination activity (coördination number 6), Al, Mg, Ti, Fe, Li, Mn, Sc, Y, and exceptionally Na and Ca (Al is between 1 and 2); and (3) those with a slight coördination activity (coördination number greater than (6), Na, K, Rb, Cs, Ca, Sr, Ba, Zr, Bi, and the rare earths. The silicates combine into infinite combinations with anions. Different ways of coupling of the silicates are discussed. The inner structure influences the outer form and characteristics of the minerals. Five main groups are given: (1) nesosilicates with characteristic $[RO_4]$-tetrahedra; (2) sorosilicates with groups of 2, 3, or more $[RO_4]$-tetrahedra, (2*a*) heterosilicates formed of (1) and (2) mixtures; (3) inosilicates with one-dimensional infinite chains of $[RO_4]$-tetrahedra, (4) phyllosilicates with two-dimensional infinite layers of $[RO_4]$-tetrahedra; and (5) tectosilicates with three-dimensional infinite frames of $[RO_4]$-tetrahedra.

Submicroscopic twinning. G. MENZER. *Naturwissenschaften*, **26** [24–25] 385–87 (1938).—M. describes a method by which submicroscopic twinning can be detected by X-ray methods. Two illustrations are given. C.H.R.

Surface chemistry of clays and shales. ALLEN D. GARRISON. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1027; *Petroleum Tech.*, **2** [1] 14 pp. (1939); *Mining Tech.*, **3** [2] (1939).—The typical clay minerals are micaceous, cleaving easily into thin hexagonal sheets. They hold water in the following forms: (1) crystal water, bound in the crystal lattice; (2) broken bond water, attached at edges or rims of the micaceous structure by the unsatisfied valences; (3) planar water, held by weak electrostatic forces on the top and bottom of the flat plates. The third form causes swelling when wet. Kaolin sheets are slightly polar and this increases the water going in between the plates. As the bentonites swell the most, they must be the most polar. In water suspension, the clay sheets let hydrogen ionize from their surfaces and thus the plate becomes the anion of a colloidal acid. Replacing the H by Na gives a sodium clay salt; this ionizes easily and the negatively charged particles repel each other, thus tending to stay in suspension. The addition of Ca or Mg salts forms a clay salt that is not easily ionized and tends to precipitate. Clay gels increase in strength rapidly at first and then increase more slowly, approaching a limit. A gel particle made by stacking highly polar sheets may deflocculate in the presence of water, while with less polar sheets sodium hydroxide may be needed to split the bonds. Shearing will also help. W.D.F.

Unique clay from the Goose Lake, Illinois, area. R. E. GRIM AND W. F. BRADLEY. *Jour. Amer. Ceram. Soc.*, **22** [5] 157–64 (1939).

Vermiculite. ANON. *Mineral Ind.*, **46**, 671 (1937).—During 1937, the production of vermiculite amounted to 24,556 tons. The vermiculite was obtained in Montana, Colorado, Wyoming, and North Carolina. B.C.R.

SEPARATE PUBLICATION

Improving the properties of clays and shales. J. G. PHILLIPS. *Can. Dept. Mines, Bur. Mines, Mines & Geol. Branch, Dept. Mines & Resources, Pub.*, No. 793, ii + 39 pp. (1938). Price, paper, 25¢.—Most Canadian surface clays are of glacial origin and have defects that require remedying as far as the clay products industry is concerned. Five representative tender-drying clays were investigated. All responded to preheating, the optimum range being between 450° and 550°C. HCl, H_2SO_4, and $FeCl_3$, used as coagulants, induced good results in the laboratory. Plant tests at Redcliff, Alta., on local clays treated with $FeCl_3$ and NaCl bore these results out. $FeCl_3$ made it safe to dry the clay and reduced the drying period by over 50%. The addition of a small amount of NaCl reduced the amount of $FeCl_3$ required; best results were obtained with 1% $FeCl_3$ and 0.5% NaCl on the basis of the weight of dry clay. The treatment has since been in regular use in the plant, resulting in increased capacity, reduced drier loss, and improvement in color and quality. Several other local concerns have adopted chemical treatment. The clays studied in this investigation exhibit a peculiar form of cracking, due not to high shrinkage but to a relative impermeability to water. The movement of water from the interior to the surface is retarded, resulting in a characteristic form of extreme cracking during drying. Determination of the moisture gradient from the surface to the interior was made by cutting successive sections about 0.15 in. thick from a core taken from the partly dried pieces and determining the moisture content of each by means of weighing bottles. Curves so obtained from untreated and chemically treated tender-drying clays were compared with those of good-drying clays. NaCl and $FeCl_3$ are effective, while HCl has no effect on the popping caused by limestone pebbles. The chemical conditioning of clays in the plastic state and deairing were investigated. In calcareous clays and shales, Na_2CO_3 improved working properties to some extent, greatly increased dry and fired strengths, slightly reduced the absorption of the fired ware, prevented scum, and slightly improved color and appearance. Its addition made some alteration of the tempering water necessary. Deairing had a much greater effect on working properties. Its effect on dry and fired strengths and absorption is comparable with that of Na_2CO_3. P. gives notes on improving the fired color and appearance of brick by the use of iron oxide and other coloring agents, glazes, slips, and engobes. Very complete bibliographies are given. Three photographs, 16 graphs. G.M.H.

Chemistry and Physics

Accurate analysis of gaseous mixtures. B. LAMBERT AND D. J. BORGARS. *Trans. Roy. Soc.* [London], **A237**, 541–65 (1939).—This method has been developed in order to analyze 10 cc. of sample with an accuracy of ±0.02%. To do this it is necessary to provide (1) a gas-measuring system which allows the measurement of gas samples under comparable conditions in regard to pressure, temperature, and water-vapor content and which is accurate to 0.001 cc.; (2) a removal system which allows the removal of one constituent by a method which proceeds to completion and which does not alter the volume of the remainder by more than 0.001 cc.; and (3) a manipulating system which collects and transfers the gas without loss. Drawings of the apparatus and a detailed description of the method are given. W.D.F.

Cathodic processes in the electrolysis of cryolite-alumina melts. A. I. BELYAEV. *Tsvetnye Metal.*, **1938**, No. 7, pp. 87–93; *Metals & Alloys*, **10** [1] MA 15 (1939).—Experiments were conducted to determine whether, in the electrolysis of cryolite-Al_2O_3 mixtures, the dissociation of Al_2O_3 and AlF_3 forms Al^{+++} ions, which are deposited on the cathode, or whether this is preceded by the deposition of Na, with the deposition of Al following as a secondary reaction. Decomposition potentials of melts of Na_3AlF_6 + 15% Al_2O_3, K_3AlF_6 + 15% Al_2O_3, and Li_3AlF_6 + 7% Al_2O_3 were in all cases equal (2.20 at 950°C and 2.01 at 1080°C) and thus not dependent on the nature of the cryolites used, indicating that the cathodic process is essentially the primary neutralization of Al^{+++} ions. The decomposition potentials of pure Na, K, and Li cryolites at 1080°C were 2.07 v. for Na_3AlF_6, 2.13 v. for K_3AlF_6, and 2.20 v. for Li_3AlF_6.

Colorimetric determination of chromium. C. F. J. VAN DER WALT AND A. J. VAN DER MERWE. *Analyst*, **63**, 809 (1938).—Directions for colorimetrically determining small amounts of chromium that occur in rocks are as follows: (1) after getting the sample in solution, precipitate the iron, aluminum, and chromium twice with NH_4OH, washing with a hot 1% $(NH_4)_2SO_4$ solution; (2) dissolve the precipitate in dilute H_2SO_4 and oxidize the chromium with ammonium persulfate in the presence of $AgNO_3$; (3) precipitate the iron and aluminum with Na_2CO_3, transfer them to a graduated flask, mix well, and filter through a dry paper; (4) to 50 ml. of the filtrate, add 10 ml. of 1:1 H_2SO_4 and 5 ml. of a freshly prepared 0.1% solution of diphenylcarbazide; make up to 70 ml.; (5) compare the violet color with that of a standard solution of potassium dichromate in a colorimeter. B.C.R.

Complete analysis of chromite. C. F. J. VAN DER WALT. *Analyst*, **63** [744] 176–79 (1938).—(*1*) *Analytical method:* Fuse 0.5 g. of sample with 15 g. of potassium pyrosulfate in a 50 ml. silica crucible, taking care to avoid an excessive temperature which makes subsequent solution very difficult. Dissolve in a 10% HCl solution and evaporate to dryness, finally heating at 105°C for 2 hr. to dehydrate the silica. Dissolve in dilute HCl and filter off the SiO_2, which is determined as usual. Dilute the filtrate, to which has been added the residue from the HF evaporation, to 200 ml. Determine the R_2O_3 group in a 50 ml. aliquot portion by double precipitation with NH_4OH in a hot solution. Concentrate the combined filtrates and destroy the ammonium salts. Dissolve the residue in 50 ml. water and 1 ml. HCl; add 1 ml. acetic acid, 5 ml. of a saturated oxalic acid solution, and 10 drops of a 1% bromocresol green solution. Heat to boiling and add NH_4OH until the solution assumes a blue color. Allow to stand overnight, filter, and wash with a dilute ammonium acetate solution. Dissolve the precipitate in dilute H_2SO_4 and titrate with $KMnO_4$. Determine MgO in the filtrate by a double precipitation with ammonium phosphate in a 10% NH_4OH solution. In a second aliquot portion of 50 ml., precipitate the R_2O_3 group with NH_4OH as before, using only one precipitation. Dissolve the precipitate with hot dilute HCl. Evaporate to a low volume and reduce the iron with $SnCl_2$, titrating with $KMnO_4$ in the usual way. Determine Cr_2O_3 in a third aliquot portion by precipitating as before with NH_4OH and washing with $(NH_4)_2SO_4$. Dissolve the precipitate with dilute H_2SO_4 and oxidize the Cr with ammonium persulfate in the presence of $AgNO_3$. Add an excess of ferrous ammonium sulfate and titrate back with $KMnO_4$. (*2*) *Behavior of certain silicates in the pyrophosphate fusion:* The silicates present in chromite consist chiefly of pyroxenes and a hydrated silicate of iron and magnesium known as bowlingite. In investigating the behavior of the silicates when acted upon by potassium pyrophosphate, results showed that some of the silicates in the sample were decomposed and the liberated silica was not made insoluble. Microscopic examinations showed that the insoluble residue consisted largely of pyroxenes with only a small per-

centage of the hydrated mineral; the refractive index of the pyroxene did not change appreciably during the fusion. B.C.R.

Convenient interpolation schedule facilitates chemical engineering calculations. D. S. DAVIS. *Chem. & Met. Eng.*, **45** [7] 383 (1938).—D. devised a scheme for tabulating the data obtained by the use of the La Grange formula for making numerous interpolations, which are appreciably more accurate than those obtained from curves. B.C.R.

Fundamental principles and applications of electrolysis with the dropping-mercury electrode and Heyrovsky's polarographic method of chemical analysis. I. M. KOLTHOFF AND JAMES J. LINGANE. *Chem. Rev.*, **24**, 1–95 (1939).—The solution to be investigated is put in a cell which has a pool of mercury for one electrode and mercury dropping from a capillary for the other electrode. The current in microamperes is measured and plotted against voltage as several volts are gradually put across the electrodes. One metal present in solution (for example, zinc with only 0.001 molar concentration) will give an S-shaped curve. Under optimum conditions, the limiting current is directly proportional to the concentration of the substance, and the voltage at a value of half the limiting current is characteristic of the substance. Several metals in solution will give a curve consisting of S-curves, one after the other. Two metals whose voltages nearly coincide may sometimes be separated by the addition of complex-forming salts, such as KCN. The polarograph obtains these curves automatically by photography. Construction and types of cells are discussed. The current in the cell is exhaustively treated mathematically. Current maxima are sometimes obtained which are reproducible, although difficult to explain. These can be eliminated by the addition of some very dilute salt solutions, *e.g.*, aluminum chloride. With this method, it is easy to detect traces of lead or cadmium in zinc or its salts, but not the reverse. The method is used for determining small amounts of aluminum, zinc, manganese, and lead in magnesium alloys. Lead ions, even 0.0001 molar, can be titrated with chromate; the end point is indicated by the current dropping to its residual value. W.D.F.

Influence of aluminum, titanium, vanadium, copper, zinc, tin, and antimony upon the polymorphic conversion of cobalt. WERNER KÖSTER AND EWALD WAGNER. *Z. Metallkunde*, **29** [7] 230–32 (1937). C.H.R.

Influence of beryllium, carbon, and silicon upon the polymorphic conversion of cobalt. WERNER KÖSTER AND EBERHARD SCHMID. *Z. Metallkunde*, **29** [7] 232–33 (1937).—The state of cobalt-beryllium is given in the range Co-CoBe and that of cobalt-silicon is given in the range Co-Co_2Si. C.H.R.

Influence of different slag-producing materials on the viscosity of blast-furnace slag. F. HARTMANN. *Stahl & Eisen*, **58**, 1029–33(1938).—The rotating cylinder method (Margules) was used to measure the viscosity of blast-furnace slags up to a temperature of 1450°C. A slag composition of 41.3 CaO, 6.9 MgO, 9.3 Al_2O_3, 0.7 TiO_2, 30.2 SiO_2, 4.6 FeO, 3.1 MnO, 0.7 P_2O_5, and 1.7% S was chosen. The variation with temperature of isoviscosity curves at 5, 50, and 150 poises is shown. Additions of CaO, SiO_2, Al_2O_3, and MgO raised the temperature, while FeO, MnO, B_2O_3, and CaF_2 lowered it. TiO_2, ZnO, ZrO_2, Na_2O, and K_2O showed intermediate effects. The measurements made over a period on the viscosity of a blast-furnace slag as the ore was changed from the normal basic to acid are recorded. L.R.B.

Magnesium–cadmium system. KARL RIEDERER. *Z. Metallkunde*, **29** [12] 423–26 (1937).—The over-structure phases $CdMg_3$, $MgCd_3$, and CdMg occurring at high temperature have magnesium-like lattices; MgCd is distorted to the rhombic. The conversion of MgCd to magnesium solid solution above 250°C was established by high-temperature photography. $MgCd_3$, established by microscopic methods by Hume-Rothery and W. Rowell, is made by long heating near the melting point. C.H.R.

Magnesium corner of the magnesium–aluminum–cadmium system. WERNER KÖSTER AND WALTER DULLENKOPF. *Z. Metallkunde*, **29** [6] 202–204 (1937).—The course of the eutectic melt equilibrium arising from the two-component system magnesium–aluminum was proved in this system. The shape of the ternary homogeneous magnesium solid solution area was established up to a content of 10% Cd. The hardening possibilities of the ternary alloy with 5 and 10% Cd were tested on a cast sample. C.H.R.

Materials containing fluorine and their analysis. F. CHERPILLOD AND J. DELEUZE. *Congr. Chim. Ind., 17th Congr., Paris*, **1937, II**, 613–18; abstracted in *Chem. Zentr.*, **1938, II**, 3840–41 (1938).—The analysis of NaF, Na_2SiF_6, $BaSiF_6$, and Na_3AlF_6 (cryolite) is discussed. M.V.C.

New phase in the iron–zinc system. JAKOB SCHRAMM. *Z. Metallkunde*, **29** [7] 222–24 (1937).—At 530°C a 6% Fe content in this system results in a new phase formation by peritectic decomposition; S. studied this by X-ray, thermal, magnetic, and microscopic methods. C.H.R.

Phases CoTe-$CoTe_2$ and NiTe-$NiTe_2$. STAFFEN TENGNÉR. *Naturwissenschaften*, **26** [26] 429 (1938).—The range of homogeneity of the NiAs-type phases in the Co–Te and Ni–Te systems is so wide that it extends from 50 to 66.7 atom percentages of Te. CoTe continually converts to $CoTe_2$ and NiTe continually converts to $NiTe_2$. The elementary volume of the Co-Te phase decreases with increased Te content. A corresponding decrease in lattice size is also noted for the Ni-Te phase. It is not surprising that melonite has been called Ni_2Te_3 and also $NiTe_2$, since, from this study, it is evident that this mineral has a variable composition. C.H.R.

Physics in 1938. T. H. OSGOOD. *Rev. Sci. Instruments*, **9** [12] 377–95 (1938). H.E.S.

Physics of solids. L. A. DUBRIDGE. *Rev. Sci. Instruments*, **9** [1] 1–5 (1938).—In the theory of solids (1) the crystal is treated as a single molecule with definite energy levels and (2) the motion of the electron in the crystal is treated as a wave motion. The groundwork seems to be laid but there are many aspects offering difficulties, *e.g.*, the so-called sensitive properties of crystals which depend greatly on slight irregularities, traces of impurities, etc. In many cases, the theory does not provide quantitative treatment, but its qualitative ideas have proved of value and are a stimulus to further experimental work. Fluorescence, photoconductivity, and photographic effects are examples. H.E.S.

Preparation of alumina and barium compounds from barium aluminate: I. K. AKIYAMA, J. KAJIMA, AND H. AIBA. *Jour. Soc. Chem. Ind. Japan*, **41** [7] 218–19B (1938).—Barium aluminates were prepared from various mixtures of pure alumina and barium carbonate with or without the addition of silica; alumina was then extracted by digesting the calcined product with pure water or alkaline solution. Results are tabulated. The marked effect of silica on the digestion of the clinker was observed; the amount of alumina dissolved from the BaO-Al_2O_3-SiO_2 clinker is smaller in the digestion with water than in the digestion with the alkaline solution. The silica content in the clinker was limited below 5% in the water digestion process but below 8% in the alkaline solution digestion process. M.V.C.

Semidirect determination of potassium oxide in feldspars. E. W. KOENIG. *Jour. Amer. Ceram. Soc.*, **22** [5] 164–68 (1939).

Solid solution series Mg-$AgCd_3$ in the ternary system magnesium–silver–cadmium. FRITZ LAVES AND KURT MOELLER. *Z. Metallkunde*, **29** [6] 185–89 (1937).—Solid solution series between the elements and Hume-Rothery compounds, proof of the solid solution series Mg-$AgCd_3$ by structure analysis, X-ray study, and thermal analysis, and the evidence of over-structure lines are shown. C.H.R.

Useful probability tables. H. V. JOHNSON. *Metals & Alloys*, **9** [11] 309–10 (1938).—J. offers two probability tables that are useful in evaluating representative sample

tests and indicating just how closely the sampling represents the true character of a batch of material being tested. F.P.P.

Volumetric analysis of copper. M. SUGITA AND Y. YAMAMOTO. *Jour. Soc. Chem. Ind. Japan*, **41** [2] 34B (1938).—Copper can be reduced to the cuprous ion in an alkaline solution with sodium sulfite. This cuprous ion can be titrated with potassium permanganate solution. After the reduction is complete, the solution is acidified to expel the excess sulfur dioxide gas. An addition of a small amount of chlorine ion in the form of sodium chloride is necessary to avoid the precipitation of cuprous oxide. The sample of solution containing about 0.16 g. of copper should be treated as follows: pour the test solution into a 500-cc. flask, dissolve it in a small amount of water, and make it slightly acid, either with sulfuric acid or sodium hydroxide solution; add 50 cc. of 10% solution of sodium sulfite and 6 cc. of 10% solution of sodium chloride; boil and redissolve the yellow precipitate in the flask (double salt of cuprous sulfite and sodium sulfite) and make the solution colorless; add 50 cc. hot sulfuric acid (prepared at this time by mixing 20 cc. of 36 *N* sulfuric acid and 30 cc. of 6 *N* sulfuric acid). The white precipitate of cuprous chloride is formed, and sulfur dioxide gas is expelled violently. Boiling is continued for 15 to 20 min. to expel sulfur dioxide gas completely and to expel excess hydrogen chloride. To fill the flask with carbon dioxide, 50 cc. of 3% sodium carbonate solution are added. Heating is discontinued and the solution is titrated with 1/10 *N* potassium permanganate solution which contains about 3% sodium carbonate. The presence of $Pb^{"}$, $Sn^{""}$, $Mn^{"}$, etc., has no effect; therefore, no preliminary separation of these metals is needed. M.V.C.

PATENTS

Making alkali metal silicates. G. R. MCDANIEL (Diamond Alkali Co.). U. S. 2,153,872, April 11, 1939 (March 7, 1935).

Production of polysilicates. DESSAUX FILS. Fr. 836,782, Oct. 8, 1937; *Chem.-Ztg.*, **63** [19] 173 (1939). D.A.B.

General

Air conditioning in industry: I. W. L. FLEISHER, A. E. STACEY, F. C. HOUGHTEN, AND M. B. FERDERBER. *Heating, Piping & Air Conditioning*, **11** [2] 107–11 (1939).—This study was conducted in the research laboratory of the American Society of Heating and Ventilating Engineers at the Pittsburgh Experiment Station of the U. S. Bureau of Mines. The physiological reactions of men while carrying on light work in atmospheric conditions including effective temperatures from 77° to 92°F with relative humidities of 60, 75, and 90% were investigated. The history of previous investigations is dealt with. Two charts. J.L.G.

Appearance and prevention of silicosis and asbestosis. ENRICO C. VIGLIANI. *Rass. Med. Applicata Lavoro Ind.*, **9**, 387–94 (1938); *Chem. Abs.*, **33**, 2244 (1939).—A review is given.

Asbestosis. R. R. SAYERS AND W. C. DREESEN. *Amer. Jour. Pub. Health*, **29** [3] 205 (1939).—In a study of the North Carolina textile mills using asbestos fiber, a hydrated magnesium silicate containing no quartz, pulmonary asbestosis was the principal defect found. Exposures ranged from 0.10 to 76 million particles/cu. ft. Persons exposed from 5 to 10 years to dust concentrations exceeding 5 million particles/cu. ft. showed definite evidence of asbestosis. Data so far obtained indicate that 5 million particles/cu. ft. is the maximum safe concentration. B.C.R.

Ceramic filters. ANON. *Chem. Age* [London], **40**, 45 (1939).—A new range of porous ceramic filtering materials has been introduced by a Glasgow firm. These ceramic materials are resistant to corrosive fluids and are made with a pore size ranging from below one micron up to several hundred microns, the distribution of pores and pore density being exactly regulated. The materials are produced in a great variety of shapes—they can be sawed, cut, or ground to suit individual requirements—and their mechanical strength and durability are very high. The materials, quartzite, biscuit porcelain, and diatomaceous or kieselguhr bodies, are described as follows: (1) Quartzite filters in the form of square or circular tile, of different thicknesses and sizes, and hollow cylinders from 2 in. to 6 in. in diameter and up to 24 in. long are produced in several grades, varying from coarse-grained bodies of extreme permeability down to a close-grained type with a pore size as low as 10 microns but of such high pore density that it ensures rapid permeability. The high rates of flow obtainable with these filters are exemplified by the P27 grade which gives a flow of 1700 gallons of water/sq. ft./hr. at 5 lb. pressure. Quartzite filters are particularly suitable for industrial filtering and aerating operations of liquids and gases, especially where resistance to corrosive fluids is essential and in reactions between liquids and gases, as it presents the gaseous reactant in the form of minute bubbles, thus giving the maximum surface for reaction. (2) Biscuit porcelain is used in filtering operations where it is necessary to separate extremely minute particles from acidic or other corrosive liquors. It resembles porcelain in color and composition, but differs from it in that it is highly porous. Its pore dimension can be regulated in size from 15 microns down to below 1 micron. The nature of its ingredients and the temperature at which it is fired ensure resistance to acids by the more siliceous bodies or to caustic alkalis (where the alumina content predominates). Biscuit porcelain is also used for electrolytic processes in the filtration of oils and concentration of rubber latex. (3) Diatomaceous or kieselguhr bodies, while less resistant to corrosive chemicals than either biscuit porcelain or quartzite, combine small pore size with high permeability and are used for the filtration of neutral, or nearly neutral, liquids. They are usually employed in the form of candles or hollow cylinders of small diameter, closed at one end or with both ends open, up to a length of 12 in. A.B.S.

Floors for industrial purposes. R. FITZMAURICE AND F. M. LEA. Read before Inst. Chem. Eng. and Inst. Struct. Eng., London, Jan., 1939; abstracted in *Chem. Trade Jour.*, **104**, 79–80, 112 (1939). L.R.B.

Industrial impairment of health and poisoning in the metal-working industry. FREITAG. *Oberflächentech.*, **16** [4] 35–36 (1939).—F. discusses the danger of silicosis in men working with sandblasting. Poisoning by nitrous gases in pickling, etching, and coloring processes, by Cr salts in Cr plating, by Pb in Pb welding, by CO in oxyacetylene welding, and by toxic gases developed in nitriding and hardening processes is also discussed. M.H.

Life and work of Henry LeChatelier (1850–1936). P. PASCAL. *Bull. Soc. Chim. Mem.*, [5] **4** [10] 1557–1611 (1937); see *Bull. Amer. Ceram. Soc.*, **16** [4] 155–63 (1937); *Ceram. Abs.*, **16** [10] 316–22 (1937). D.A.B.

PATENTS

Repairing cement for ceramic objects. E. ROSENTHAL. Brit. 500,575, Feb. 22, 1939 (Aug. 12, 1937).

Satin white pigment and process of making. L. T. WORK. U. S. 2,145,149, Jan. 24, 1939 (Feb. 4, 1935). The process comprises treating finely divided clay with sulfuric acid, producing thereby a solution containing aluminum sulfate together with coloring impurities and an insoluble clay residue, removing coloring ingredients from the solution, and reacting the so-purified solution with hydrated lime in the presence of the clay residue.

Tile for use in sewage filters. J. E. TUCKER. Brit. 500,378, Feb. 22, 1939 (Sept. 15, 1937).

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